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THE NEW YORK CENTRAL TUNNEL under Park Ave. is the subject of an order issued on Aug. 22 by the New York Board of Health, addressed to the railway company. The order in part is as follows: That the sewers under the surface of the floor under the tunnel be properly closed gas tight; that proper and sufficient water-closet accommodations be provided for the employees of said tunnel; that the brick and stone sustaining walls between the two sections of the tunnel be removed and proper and sufficient steel girders and columns be placed in lieu of same; that the small shafts which ventilate the tunnel between 67th and 71st Sts. and between 81st and 95th Sts. be enlarged and extended on every block in a like manner to conform with the ventilating shafts from 56th to 67th St.

A PASSENGER CAR VENTILATION SYSTEM has been perfected by the Safety Car Heating & Lighting Co., and a train on the New York Central has just been equipped with it, while a Pullman car running on the Erie Railroad from Jersey City to Tuxedo has had the system in use for some time. The system combines ventilation and cooling. Two fans are placed in each car, one at each end, and are driven by compressed air furnished by an additional air pump on the locomotive, the air thus supplied being conveyed the entire length of the train by means of the steam pipe which heretofore has been out of use during the summer months. On each car is placed a storage tank into which the air is first carried, and from there it is taken to the fans by means of a very small pipe. The fans weigh only about 6 lbs. each, and are driven by the reaction of the issuing jet of air. These fans not only give a breeze through the car, but introduce into it a large amount of cold fresh air by the expansion of the compressed air which drives them.

A NEW CAR BARN for the Brooklyn Heights R. R. Co. is being erected to take the place of the one destroyed by fire last spring. The proposed building will be unusual, in that there will be no roof over the yard where the cars will be kept; fence walls being the only means of enclosure. It is maintained that the cars, being built to withstand all sorts of weather, will suffer no injury by being stored in the open. The yard will be 200 ft. wide on Ave. N, and will run back 775 ft. on East 49th St. The building proper will be located in the center and front of the ward, and will have a wing in the rear, making a T-formation. This building will be 130 ft. wide and 275 ft. deep. It will be built in two sections. The front section on the second floor to be used for the superintendent's offices and to contain quarters for the employees. Tracks to the shop and yard will run through this section, on the ground floor, on each side. The rear section will be used for the shops. Handsome club rooms in the front section will afford abundant means to the employees for recreation during off hours. The bowling alleys will be the most interesting feature here; the toilet, bath and locker rooms will be commodious and complete. The shops will be equipped with the best and most recent devices for the rapid repair of the cars. The walls in the main building will be plastered and wainscoted to the sills. All woodwork on the second floor will be of the best yellow pine. The two sections of the building will be separated in case of fire, by Kinnear steel rolling doors on the first floor and by heavy folding iron shutters on the second floor. The walls will be of red brick, trimmed with axe-finished bluestone. The contract was awarded to The Eastern Construction Co., under the firm management of Messrs. McKee & Beers, 52 Classon Ave., Brooklyn. They are pushing the work vigorously and expect to have it completed by about Dec. 1.

THE MOST SERIOUS RAILWAY ACCIDENT of the week was a collision caused by the parting of a freight train at Nyack, about 30 miles west of Kalispel, Mont., on the Great Northern Ry., on Aug. 30. Altogether 36 persons were killed and 13 were injured. The following statement, describing the accident, has been issued from the offices of the railway company at St. Paul, Minn.:

About 8.30 o'clock last evening (Aug. 30), at Essex, Mont., 18 cars broke loose from the rear end of a freight train and ran down the hill 16 miles to Nyack Station, where they overtook passenger train No. 3, which was just starting out from that station. In the collision P. T. Downs, Assistant General Superintendent, in charge of the lines west of Minot, N. D., was killed, together with his son, Kirk T. Downs; his cook, Henry Blair, and 33 laborers, who were moving West in a coach attached to the rear of the train. None of the regular passengers on the train were injured. The wreck took fire and the bodies of all save five of those killed were burned. In addition to those killed, 13 were injured.

ANOTHER SERIOUS RAILWAY ACCIDENT occurred on the Northern Central R. R. at Fairville, N. Y., about 10 miles north of Newark, N. Y., on Aug. 29. One person was killed instantly and 10 others have died as the result of injuries received. About a dozen others were less seriously injured, most of them being scalded. The train was running at nearly 40 miles an hour. At the approach to the station at Fairville there are a curve and a gravel pit. For some unknown reason the engine jumped the track while passing the gravel pit. The force of the accident turned the engine completely around, throwing the five cars on their sides. The trainlond of about 150 passengers was thrown into the ditch. The engine and all the cars were badly broken up, and the steampipes running under the cars were broken in several places. This accounts for the large number of people scalded.

A DISASTROUS BOILER EXPLOSION took place on Wednesday afternoon, Aug. 28, on the steamboat "City of Trenton," of the Wilmington Steamboat Co., near Torresdale, Pa., while on a trip on the Delaware River from Philadelphia to Trenton, N. J. Eleven persons are known to have been killed, 17 are missing and are probably dead and 25 others were injured. According to press reports, the steam pipe leading from the port boiler burst, and was followed immediately by an explosion of the port boiler, which was projected forwards and out of the port side of the vessel. It now lies at the bottom of the river in 30ft. depth of water, about 50 ft. distant from its position before the explosion. The vessel caught fire after the explosion and it was run ashore, grounding in 4 ft. of water. The boiler that exploded is said to have been nearly new. It is of the locomotive type, 20 ft. 2 ins. long, 68 ins. diameter. It was built under the rules of the U. S. Supervising Inspectors. The plates were ⅝-in. in thickness, 60,000 lbs. tensile strength and 54% reduction of area. The boiler was tested by hydraulic pressure up to 263 lbs., and was licensed to carry 175 lbs. The safety valve was set to blow off at 160 lbs., and the chief engineer of the vessel says the pressure carried at the time of the explosion was 150 lbs. The longitudinal seams were double butted and strapped, triple riveted. The steamer was built by the Neafie & Levy Shipbuilding Co., of Philadelphia. The boiler being at the bottom of the river, no satisfactory theory of the cause of the explosion can be given. Coroner Dugan, of Philadelphia, is reported to say that any official examination of the wrecked steamer, to discover the cause of the catastrophe, will have to be made by the United States Inspectors, as steam vessels are under their control.

AUTOMATIC BLOCK SIGNALS are to be in operation by the end of the present month on the entire main line of the Lehigh Valley R. R., from New York to Buffalo. Mr. Chas. S. Lee, General Passenger Agent, informs us that the only sections still unequipped are those from Odessa, N. Y., to Geneva, Jc. and from Manchester to North Leroy. The erection of signals on these sections is in progress, however, and it is hoped to have them all in operation before October.

CRACKS IN ST. PAUL CATHEDRAL, which is located near the business center of London, have caused anxiety of late to those responsible for its care, and its condition is being discussed in the London papers. The cathedral, which was built by Sir Christopher Wren, is founded on a bed of yellow clay or "potter's earth," which loses its stability when dried. This potter's earth is 4 to 6 ft. thick and is underlaid by sand and gravel which continues for a depth of 10 to 20 ft. down to the hard London clay. Unequal settlement of the foundations caused cracks to develop in the structure in the first century of its life, and heavy iron ties were introduced in the walls at various points to prevent further deterioration. Within the last fifty years, however, other cracks have developed and it is believed that the draining of the sand and potter's earth underlying the base of the great structure is causing further settlement. Numerous sewers have been built in the vicinity and the construction of the London Underground Railway under Queen Victoria St. involved the making of a deep trench within 530 ft. of the cathedral. More recently the Waterloo & City and the Central London railways have been built, the latter passing only 460 ft. from the center of the dome. The old cracks, which had been carefully filled, reopened when these excavations were made, and new cracks formed. Iron ties have been fixed to prevent the cracks extending, and bridges of cement which stand out about a quarter of an inch are placed across the cracks, so that their breaking will give warning of any widening; but the church authorities are likely to protest against the building of new underground roads in the cathedral's vicinity.

STATISTICS OF VESSELS LOST, CONDEMNED, etc., in 1900 have been published by Lloyds Register. According to these figures, the gross reduction in the effective mercantile marine of the world during the year amounted to 848 vessels of 677,182 tons, excluding all vessels of less than 100 tons. Of this total 296 vessels of 386,304 tons were steamers and 552 of 290,878 tons were sailing vessels. The summary exhibits interesting data as to the relative frequency of the different kinds of casualty, etc., which conclude the existence of vessels. Strandings and kindred casualties which are comprised under the term "wrecked" are much the most prolific cause of disaster. To such casualties are attributable 47% of the losses of steamers and 45% of the losses of sailing vessels. The next most common termination of a vessel's career is by condemnation, breaking up, etc.; about 17% of the vessels removed from the merchant fleets of the world are accounted for in this manner. Of the remaining causes of loss, collision is the most general for steamers, about 12%, while for sailing vessels cases of abandonment at sea come next in order of frequency, also about 12%. Cases of abandoned, foundered and missing vessels, taken collectively, comprehend 19% of the losses of steamers and 28% of the losses of sailing vessels.

TWO SEA-GOING SUCTION DREDGES are to be built for the U. S. Government, one for the Southwest Pass work and the other for the Cumberland Sound work. The Southwest Pass dredge is to be built of steel and the Cumberland Sound dredge is to be built of wood. The dimensions of the Cumberland Sound dredge are: Length between perpendiculars, 185 ft.; length over all, 200 ft.; molded beam, 40 ft.; extreme beam, 40 ft. 10 ins. The keel is to be of oak, 12 × 14 ins. in 50-ft lengths. The frames are to be of oak. The planking and ceiling are to be of Georgia pine. The propelling engine is to be of the fore-and-aft vertical, inverted, compound condensing type, with cylinders of 22 and 24 ins. diameter and 30 ins. stroke. The vessel is to be equipped with two boilers of the Scotch return tubular type, 14 ft. diameter and 12 ft. long. The pumping engines are to be two in number, direct connected to the 18-in. sand pumps. The type of engine is to be vertical, inverted compound condensing, with cylinders 14 ins. and 26 ins. and a stroke of 18 ins. The dredging pump is to be 18 ins., of centrifugal type, and extra heavy construction, especially adapted for dredging. The pump runner is to be of the open side type, having four blades curved to a uniform radius. The blades are to be covered with renewable steel plates for their entire working surface. The pumps are to be capable of raising and discharging against a head of 14 ft. 85 cu. yds. per minute. When working in good material and in water 32 ft. deep each should lift from the bottom and should discharge into the bins 10 cu. yds. per minute. The number of revolutions of the disks of these pumps should be between 200 and 250 per minute. The dimensions of the Southwest Pass dredge are to be: Length between perpendiculars, 260 ft.; length over all, 271.5 ft.; molded beam, 47½ ft.; molded depth, 23 ft. The propelling machinery will consist of two fore-and-aft vertical, inverted, compound condensing engines, with cylinders of 20 and 40 in. by 30 in. stroke. All pumps are to be independent. There will be four boilers of the Scotch return tubular type, 13 ft. 6 ins. in diameter and 12 ft. long. The dredge is to have a complete electric light plant. The pumping engines, two in number, are to be of the vertical, inverted, compound, condensing type, with cylinders of 16 and 32 ins. diameter by 20 ins. stroke, and are to be direct connected to the 20-in. sand pumps. The dredging pumps are to be of the centrifugal type, of extra heavy construction, especially adapted for dredging, with 20-in. suctions. The pump runner is to be of the open side type, having four blades curved to a uniform radius. These pumps are to be capable of raising and discharging against a head of 16 ft. 95 cu. yds. of water per minute. The number of revolutions of the disk of these pumps while dredging is to be between 200 and 220 per minute.

RECONSTRUCTION OF A WATER AND ELECTRIC LIGHTING STATION AT WARREN, O.

Following upon changes in the ownership and management of the Warren Water Co., of Warren, O., some improvements to the plant were undertaken and carried out during the year 1899. The Warren Water Co. was organized in 1886, and established water-works on the east bank of the Mahoning River, about ¾-mile above the center of the town, or village, which then contained 5,000 or 6,000 inhabitants. The supply was taken from the Mahoning River above a dam which had been constructed some 30 years before for water power or mill purposes. A mill site was utilized in part in the construction of the works, but a new brick station was then erected upon the steep bank of the river and the necessary pumping machinery installed. A distribution system of 12 miles of pipe was provided, and also a standpipe 22 ft. in diameter and 140 ft. high, which was placed near the pumping station. Some crude and inexpensive attempts to filter the water were made at the time the works were established, but, proving unsatisfactory, these were abandoned and filters of the Warren type were finally installed in 1894, partly upon the foundations of the flour mill, which had years before been operated by water power. The filters were six in number, of the gravity type, and were provided with ample sedimentation and clear water basins. Before this date, or in 1890, an electric light company was organized by parties interested in the water company, and an addition was made to the original pumping station, where new boilers and Westinghouse engines were provided, for the street and incandescent lighting called for by the new franchise. In 1899 the electric light plant had been outgrown, and there was no convenient space in the immediate vicinity for the changes and extensions which the service required. The first purchase by the water company included land on both sides of the river, and in making provision for the increased service it was decided to erect a new electric light station on the opposite or west side of the river and to develop the water power, which could be used under a head of 6 ft. to 7 ft. The accompanying plans and photographs will show the extent and character of the new work.

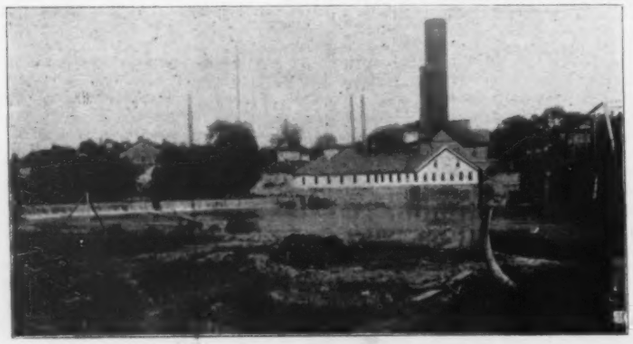


Fig. 1. General View of Original Plant on East Bank.

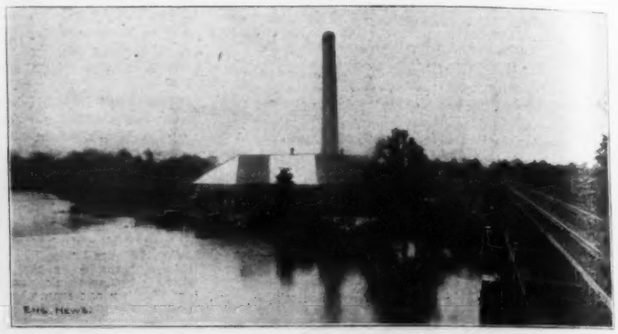


Fig. 5. View of New Power Station on West Bank.

WATER-WORKS AND ELECTRIC LIGHTING PLANT AT WARREN, O.

Fig. 1 shows the original plant upon the east side of the river. The building in the foreground contains the filters, and the electric light plant was first installed at the left of the pump house, which is shown with its chimney between the filter house and the standpipe. Fig. 2 is a ground plan, with partial elevations, of the new building and work on the west side of the river. Figs. 3 and 4 are interior views after completion. Fig. 5 is a distant view of the station from the bluff on the east side of the river.

Extensive beds of quicksand were found upon the west side of the river, making it necessary to go down about 14 ft. to the rock for a foundation for the walls of the building, as well as for the machinery and chimney. The concrete, and, in fact, all of the masonry and the brick walls, are in American cement mortar, no lime having been used in the construction. The building was so located that one of the walls helps to form a canal or head race for the wheel, and the opposite side was formed by strengthening the abutment, which received the thrust of the curved dam and had shown some evidence of weakness.

The wheel is a 61-in. Trump turbine, and was introduced to operate a pump and to enable some of the power to be used upon the main line shaft. There is one cross-compound condensing Cooper engine of 650 HP. and one condensing Harris engine of about 250 HP. Friction clutches are so introduced that the power pump can be run by the water wheel or by the engines, and the use of the pump can be discontinued and the power of the

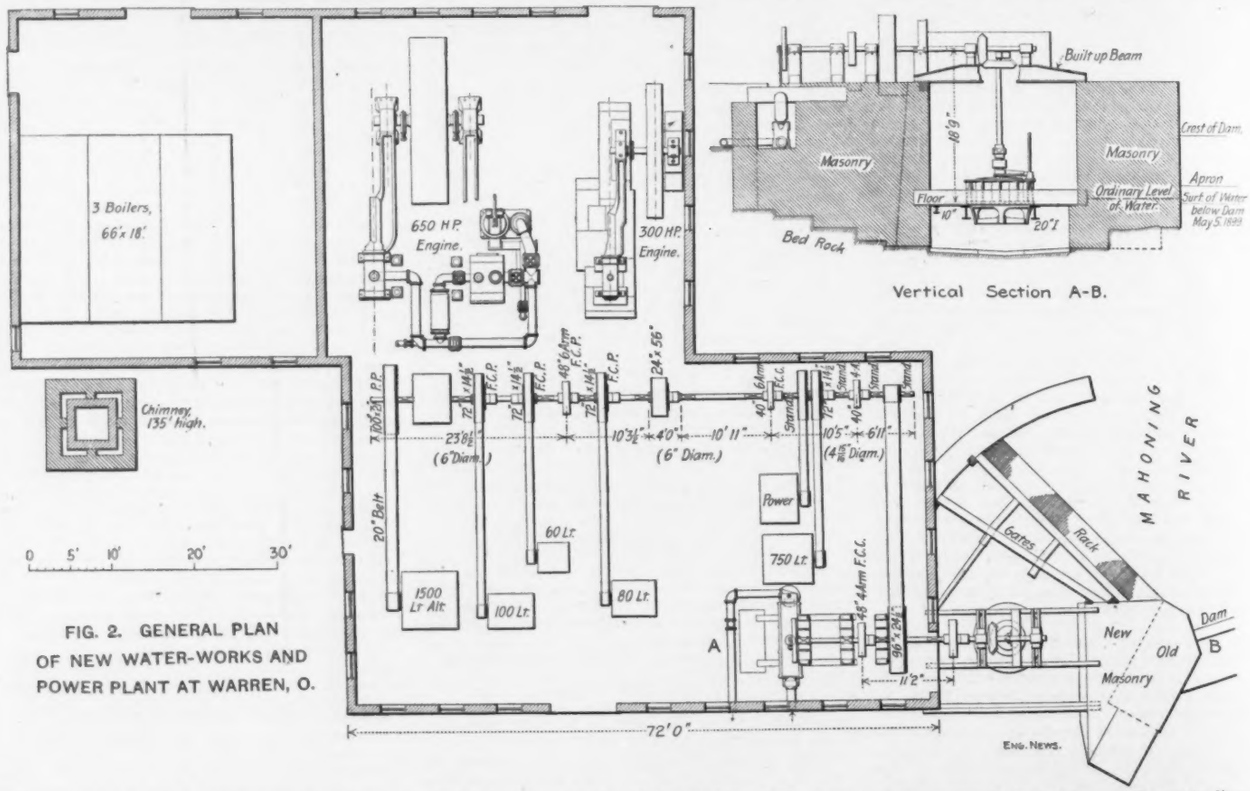


FIG. 2. GENERAL PLAN OF NEW WATER-WORKS AND POWER PLANT AT WARREN, O.

wheel applied to the engine shaft at any time. This will be evident from the general plan, Fig. 1, showing the machinery. A force main was laid under the bed of the river to strengthen the fire protection system upon the west side, and an intake pipe from the clear-water basin in the filter house was also laid to supply water to the power pump on the west side, from which it is delivered back to the standpipe and city through a force main, as indicated upon the sketch. About two years ago a power circuit for the convenience of parties having occasion to use power in small quantity in the city of Warren was established, and is now supplied with current from one 100-K-W. machine and another of 75 K-W. capacity. Brush machines furnish arc lights for the streets, and the incandescent lighting is now done from three machines of 200, 100 and 50 K-W. capacity, respectively. The boiler room now contains three horizontal tubular boilers, 5½ × 18 ft., carrying steam pressure of 125 lbs. per sq. in. The chimney is 135 ft. in height, and has a double flue.

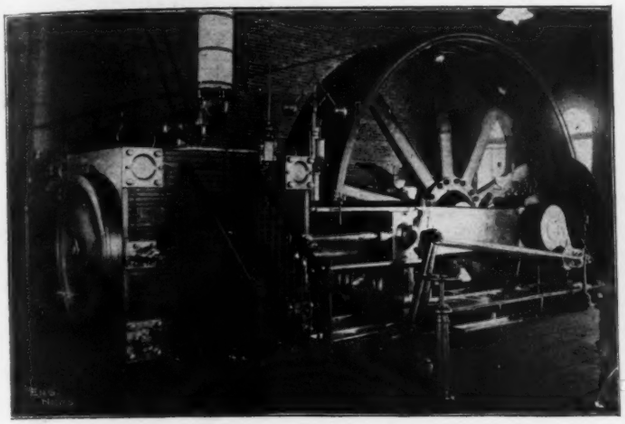


Fig. 3. 650-HP. Cooper Cross-Compound Condensing Engine.

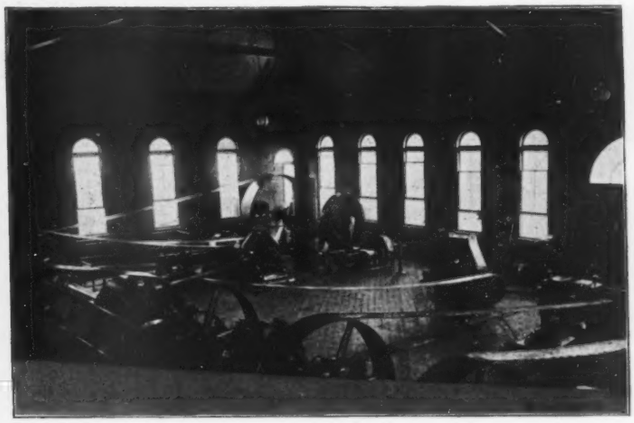


Fig. 4. Interior View of Dynamo Room.

FIGS. 3 AND 4. INTERIOR VIEWS OF WATER-WORKS AND POWER PLANT AT WARREN, O.

The roof trusses of the power house were furnished by the Wrought Iron Bridge Co., of Canton, O., and it may be noted that the building was of such dimensions that the principal diagonal truss which supports the roof over one part of the building was duplicated in reverse position to carry the roof over another part, thus giving a maximum number of similar trusses. The roof is of Vermont slate upon 2-in. matched planks transverse to the purlins.

Some facts connected with the dam may be of interest: It was built in 1861 upon a level rock bottom by placing hewn trunks of trees parallel with each other and the stream and close together, with the larger ends approximately outlining a curve on the down-stream side. Then, upon a selected day, a large number of carpenters built the dam proper, using planks about 10 ins. in width, laid one upon the other, from the timber foundation to a height of about 7 ft. The ends were properly cut to insure a bearing and receive thrust, and the whole work was carried up so quickly that no trouble was experienced from the water. Abutments were provided to take the thrust or pressure at the ends of the dam. The position of the dam upon the tree trunks was about 8 ft. from the larger and lower ends, thus affording an opportunity to brace or strengthen the dam upon the apron, which rested upon the solid rock. The up-stream side was filled to a slope of about 1 on 2.

The rock in the bed of the river is of such a character that upon exposure to the air it rapidly crumbles away, and in making the above described changes it was discovered that in the interval since the erection of the dam the entire foundation, or rock support, for a distance of about 50 ft. near the center of the curve had been completely removed to a depth of 7 ft. and over an area extending backward or up stream a distance greater than the length of the apron. The dam was therefore unsupported over that portion of its length, except in so far as it was held by the thrust against the abutments and by the strength or elasticity of the foundation timbers acting as so many beams supported at only one end. It seemed evident that the removal of such a large quantity of rock so far back from the end of the apron could scarcely have been done by currents of water alone. On account of the converging overflow from the dam, it is possible that more than the ordinary amount of air was mixed with the water at the central portion of the dam in such a manner that it came in contact with the rock beneath the timbers more than would have been the case with a straight dam. The repeated presence during high water of particles of air in the water and in contact with the rocky surface would no doubt tend to slake or crumble it away in very much the same manner that would follow full exposure to the air for a short length of time.

Restoration was made or the dam strengthened by putting in cribs of timberwork filled with stone and gravel. At the down-stream corners holes were drilled in the rock to a depth of 4 ft. and 2½-in. square bars of steel were inserted and filled in with cement mortar, while the original timbers of the dam (still in very good condition) were drift-bolted into the cribwork and a new apron put in place of the old.

The quantity of water supplied for domestic and manufacturing purposes at Warren has been reduced about one-half during the past two or three years, or since the above-mentioned change in the management. This reduction is due to good work by the superintendent and to the introduction of a power circuit from which power at low rates has been substituted for water motors. The yearly reports of the health officer contain no criticism as to the quality of the water furnished, but instead advises those who are still using well water to change to the public supply. To insure still more satisfactory results, as well as to diminish the cost of filtration, a laboratory has recently been established and fitted up with the necessary apparatus, including an incubator for work at body temperature. This work was done under the direction of Prof. E. G. Smith, of Beloit, Wis., and the determinations are now made by the Superintendent. The water in the river contains ordinarily from 2,000 to 3,000 bacteria per cubic centimeter, although in times of high water the number is greatly increased. It also appears that the numbers increase in the Mahoning below Warren, as some recent determinations show about 8,000 at Youngstown. The percentage removed averages above 98%, being the greatest at those times when the river contains the largest number. During the heaviest freshets there is not quite enough lime in the water to take care of the alum used as a coagulant, and at such times a little free lime or soda is added to the water. The effluent is at all times clear and a satisfactory drinking water for the consumers.

The president of the company is Mr. R. B. Dobson, No. 2 Wall St., New York city, and the secretary and treasurer is Mr. C. D. Backus, Cashier of the First National Bank of New York. Mr. C. E. Inman, of Warren, O., is the superintendent. The new work was designed and its construction was supervised by Mr. H. F. Dunham, M. Am. Soc. C. E., 220 Broadway, New York city.

INDEXING RAILWAY MAPS AND DRAWINGS.

By R. C. Vial.*

At the present time railway managers and large corporations of all kinds are devising various methods and expending large amounts of money in reconstruction, new equipment and general improvements to reduce cost of operation. With so much improvement going on for the economical operation of a railway, is there not room for important improvement in some of the smaller details?

In many railway drafting rooms little attention is paid to an economical system of indexing and filing of records, usually through lack of time for such work. A good index system in connection with an office means a saving of time and energy. Time spent in looking for a drawing or record, due to lack of system, is lost time. A man at $200 a month spending half a day with several assistants looking for some record which, under different circumstances, might be had in a few minutes, does not tend toward low operating expenses, nor the high efficiency of the office.

The system of indexing here described has proved very satisfactory in the drafting room of the Chicago & Western Indiana R. R. This road is a terminal line of Chicago, owning terminal facilities, tracks and about 50 miles of right of way, which are leased to the following tenant lines: The Chicago & Eastern Illinois, the Chicago & Grand Trunk, the Erie, the Wabash, the Atchison, Topeka & Santa Fe, and the Chicago, Indianapolis & Louisville railways.

The method of indexing used is based on a decimal system, and will be described under the following heads: I., Decimal Outline; II., Card Index; III., Method of Indorsing and Filing Drawings; IV., Indexing of Survey Notes.

I. DECIMAL OUTLINE. The general method of using a decimal index is too well known to require explanation here. It has been tried to such an extent that it is replacing other methods of indexing, and is no longer an experiment. Its great elasticity, convenience in filing and adaptability are features which commend its use for all varieties of indexing. No one outline, perhaps, would fill the requirements of two offices, yet the general scheme and operation would be the same in both.

The decimal system described below was put under way by Mr. F. K. Vial, Assistant Engineer of the C. & W. I. R. R., in 1898. The idea of the system was to classify data under subjects and territory. The outline was worked up by Mr. R. B. Ketchum, of the company, who is now Assistant Engineer on the Chicago & Alton Ry. The

*Chief Draftsman; Chicago & Western Indiana R. R., Chicago, Ill.

outline was arranged to cover the requirements for the matter then on file in the drafting room. The drawings at that time numbered about 500. The following is the outline as originally used:

SUBJECT MATTER.

100. Main Track.
200. Side Tracks, Industry Tracks, Special Layouts, Yard Tracks.
300. Track Details and Standards.
400. Bridges.
500. Buildings and Station Grounds.
600. Right of Way, Real Estate, Leases and Legal Matter.
700. Track Elevation.
800. Signals.
900.

SUBDIVISION OF SUBJECT MATTER.

100.
110. 20 ft. to an inch.
120. 50 " " " "
130. 100 " " " "
140. 200 " " " "
150. 400 " " " "

200.
210. Terminals, Yards and Accessories.
220. Industry Tracks.
230. Side Tracks.
240. Special Layouts.

300.
310. Crossings.
320. Frogs.
330. Switches.
340. Switchstands.
350. Rail Sections and Angle Bars.
360. Minor Track Materials.

400.
410. Superstructure.
420. Masonry.

500.
510. Stations.
520. Roundhouses and Turntables.
530. Water Tanks and Cranes.
540. Coal Chutes.
550. Industry Buildings.
560. Section and Flag Houses, Watch Towers.

600.
610. Right of Way.
620. Real Estate.
630. Leases.
640. Contracts.
650. Legal Matter.
660. Statistics and Tables.

700.
800.
900.

The divisions of territory originally used were the same as those used at present, which are given below. With slight modification, the arrangement of drawings in the files and the indorsement of drawings has been retained and is described below.

It may be said that at the time the above outline was devised about 75% of the drawings pertaining to the Chief Engineer's office were filed in the Chief Engineer's private room; the other 25% (comprising about 500 drawings) were the later drawings and were kept in the drafting room, the two rooms being separated by considerable space. In neither room at that time, 1898, was there a complete index of the matter on file in either. In the former, some of the drawings were kept in drawers, according to subjects, as bridges, viaducts, station plans, etc., and were not covered by any index; others were kept in pigeon holes, and were indexed in book form under subjects for a few main divisions of territory. The index number of a drawing was a key only to its position in the files. Still another portion of the miscellaneous drawings were kept in drawers, and were not covered by the index. In the drafting room there was no index of any kind. The drawings were filed in drawers.

In 1900 it was decided to file all the drawings in the drafting room. The drawings moved were entirely new to the employees in their new quarters, and hence were practically lost without some system of indexing and filing which would cover the whole field. It was also decided at this time to enlarge the decimal outline to cover any record on file in the drafting room.

The result is the present outline given below, which received the approval of Mr. E. H. Lee, the Chief Engineer, who ordered the work of indexing carried on to completion, and who personally has given every encouragement to the work. The old book index referred to is still retained for use by any one who might be more familiar with it than with the new scheme, by inserting the new number for the drawing along with the old file number.

MAIN DIVISIONS OF SUBJECT MATTER.

100. Maps, Drawings, Etc., pertaining to Maintenance of Way.
200. Survey Notes.
300. Estimates, Prices, Computations.
400. Diagrams, Tabulated Statements, Reports, Tests.
500. Printed Matter, Specifications, Trade Catalogues.
600. ....
700. Track Elevation.
800. Signals and Interlocking.
900. Foreign Matter. (Other Roads.)

MINOR DIVISIONS OF SUBJECT MATTER.

10. General Maps and Profiles.
11. Line maps (to date). [Scale, 1-in. = 50 ft., and 1-in. = 100 ft.]
12. Line maps (obsolete, kept as matter of record.)
13. Profiles, elevations, cross-sections.
14. Maps of whole system.
15. Maps of adjacent territory.
....
....

20. Yards, Industries, and Special Layouts.
21. Yards and accessories.
22. Industry tracks and industries.
23. Side tracks.
24. Special layouts.
25. Connections with other roads.
26. Proposed rearrangement of tracks.
27. Proposed tracks.
....
....

30. Maintenance-of-Way Standards.
31. Roadbed standards.
32. Signs and signals.
33. Cattleguards.
34. Crossings (street and road).
35. Gates.
36. Fences.
37. Telegraph lines, wires.
38. Track tools.
....
....

40. Track Details.
41. Crossings.
42. Turnouts.
43. Crossovers.
44. Slip switches.
45. Frogs and guard rails.
46. Switches and switchstands.
47. Joints, angle bars, rail sections.
48. Ties.
49. Minor track details.

50. Buildings and Structures.
51. Stations.
52. Freight houses, warehouses, supply houses.
53. Power plants.
54. Section houses, towers, flagmen's houses.
55. Roundhouses and shop buildings.
56. Turntables.
57. Water tanks, pump houses.
58. Coaling stations.
59. Docks and elevators.

60. Bridges and Masonry.
61. Culverts, arches.
62. Pile bridges, trestles.
63. Trussed bridges, viaducts.
64. Girder bridges.
65. Miscellaneous bridge attachments.
66. Bridge masonry.
67. Retaining walls.
68. False work.
69. Subways.

70. Legal Matter.
71. Right of way.
72. Real estate.
73. Leases.
74. Contracts.
75. Special cases.
....
....

80. Sewers and Plumbing.
81. Sewers.
82. Surface drainage.
83. Heating, steam pipes.
84. Water supply and mains.
85. Air pipes.
86. Lighting.
....
....

90. Other Departments.
91. Motive power department.
92. Operating department.

MAIN DIVISIONS OF SUBJECT MATTER.—The main divisions of subject matter are quite distinctive.

100. Contains all maps, profiles, detail and general drawings pertaining to maintenance of way.
200. All field notes and data recorded in field books.
300. Estimates for various pieces of work; figuring book computations.
400. Diagrams, tables, tabulated statements, reports, tests.
500. Books, pamphlets, trade catalogues, specifications.
600. ....
700. Drawings pertaining to track elevation.
800. Drawings pertaining to signals and interlocking.
900. Contains all drawings from other roads and other sources.

MINOR DIVISIONS OF SUBJECT MATTER.—The greater part of these divisions are distinctive. Some explanation, however, may be needed. This will be done by bringing the minor divisions under 100 of the main divisions of subject matter.

111. Main line maps at a scale of 1 in. = 50 ft., and 1 in. = 100 ft., covering a considerable amount of territory. Maps that are kept up to date. Main line maps of these scales covering but a very limited amount of territory are classed under 124.
112. Maps which are now obsolete owing to having been replaced by later maps, but are kept as a matter of record.
113. Profiles, contour maps, soundings, elevations, cross-sections.
114. General maps of the whole system usually on a small scale.
115. Maps of adjacent territory made for special purposes.
121. On maps classified under 111 all tracks are shown. If, however, a yard along the line is drawn up to show the yard primarily, the number of the drawing is 121 instead of 111.
122. Drawings made to show present or proposed industry tracks and drawings showing the layout of industry buildings.
124. All drawings of parts of the line not included in 121 and 122 which are necessitated for some purpose for which the main line map 111, of the territory in question will not answer as to scale or amount of detail. In the work of indexing and filing the old records of the office a large accumulation of small tracings was encountered covering small areas of the main line. These were evidently made before a reliable line map was available; 124 was introduced, partly to accommodate these drawings.
125. Maps showing connections with other roads.
126. Maps for the purpose of showing proposed alterations in tracks.
127. Proposed additional tracks.
130. The subdivisions under 130 are distinctive. Drawings under this head are mostly standards.
134. Details pertaining to street and road crossings. This number does not conflict with 141, which pertains to the rail details of crossings of steam or street railway crossings, while 134 pertains rather to the planking of such crossings.
140. This division refers to detail of tracks, and is not to be confused with alinement of tracks. Any map which shows alinement only, through crossings, slip switches, crossovers, etc., comes under 124.
141. Crossing details, lengths, angles, etc.
142. Standard turnouts and crossovers for various frog numbers.
143-147. Standard and special work.
148. Arrangement of ties for special layouts.
150. Plans and details of buildings. Subdivisions are distinctive.
160. Bridges. Subdivisions are distinctive.
170. Drawings made for real estate agent and legal department.
171. Maps pertaining to right of way.
172. Maps pertaining to real estate owned by company.
173. Maps pertaining to leases. Plats to accompany leases.
174. Plats to accompany contracts.
175. Plats made for special cases, as damage and accident cases.
180. Drawings showing location, size, and other information relating to sewers, drains, water pipe, steam pipe, air pipe, electric lights, etc. The subdivisions under this head are distinctive.
190. Drawings pertaining to other departments than maintenance of way, which are filed in the drafting room.

In the above outline any number divisible by 10 represents a class of which the next nine numbers numerically are further subdivisions of that class. Any number divisible by 100 represents a main division of subject matter. These numbers divisible by 10 and 100 represent not merely individual numbers, but all the numbers under them in their respective subdivisions. A drawing of a general nature may be classified by such a number when it could not be otherwise.

The minor divisions of subject matter are used with each of the main divisions in the same manner as explained above for the 100 class. For example, taking 21 in connection with each of the main divisions, we would have the following numbers, with an example of each:

121. Map of yard.
221. Survey notes of yard.
321. Estimate in connection with yard.
421. Statement of capacity of yard.
521. An article in an engineering paper on yards.
721. Yard on track elevation work.
821. Interlocking in connection with yard.
921. Map of yard furnished by a foreign road.

With the above classification of subject matter is used a classification of territory in the form of a decimal. This classification is of no general interest, and is only given to show the manner in which it is used.

0.00 Whole system. (For standards, etc., which apply to whole system.)
.11—.50. Main line.
.50—.60. Dolton Branch.
.60—.70. South Chicago Branch.
.70—.80. Belt Division.

Under each of the above divisions of territory are minor divisions. For convenience, a lithograph map of Chicago is hung on the inner side of a door of the filing case (there is no vault), with each division of territory boldly marked with its proper number. This map enables an inexperienced person in the office to draw from the filing case a drawing for any part of the line with very little study or confusion. On a large system a division by station numbers or by mile posts might be advisable. With such an outline as described above the position of territory on the ground determines the position of drawings pertaining to that territory in the files.

II. CARD INDEX.

Every drawing in the office has a number according to the decimal outline described above. This number is entered upon a blank card, with a brief description of the drawing in the following form:

121.12—17. Tracing. File Case 1.
Yards.
18th St. Plan "A" for proposed extension.
Scale, 1 in. = 50 ft.
April 15, 1891.

On the first line in the upper left hand corner of the card is the number of the drawing. On the same line in the center of the card the physical characteristic of the drawing, whether a tracing, brown paper drawing, lithograph, blue print, or whatever the case may be. In the upper right hand corner the number of the file case or drawer in which the drawing may be found. On the second line, to the right of a vertically ruled line, the classification of the drawing under the minor divisions of subject matter outlined above. The object of this line is for intelligibility of cards to a person not familiar with the decimal outline, in which case the cards may be referred to directly according to subject matter. The third line and four others are available for description of the drawing. On the two lines following this description the scale and the date of the drawing are given. The date is often necessary to identify a drawing with its card. For example, there might be cards for plans "B," "C" and "D" following the card for plan "A" above. The chance of any two of these drawings having the same date is rare, hence a drawing and its card can always be identified by the decimal classification and date. It is often desirable for reference to know the scale of a drawing. The description of two drawings might often be identical were it not for the scale of each.

It is desirable to cross-index cards freely in order to classify the different divisions of subject matter that may be on a drawing and also to avoid any personal factor in indexing. For example, the above card should be cross-indexed under proposed tracks, in which case the card is written up as follows:

127.16—17. Filed under 121.16—17. File Case 1.
Tracing.
Proposed tracks.
18th St. Yard. Plan "A" for proposed extension.
Scale, 1 in. = 50 ft.
April 15, 1891.

This drawing may also show a proposed scheme for drainage, for which a card under drainage (181) should be written as follows:

181.16—17. Filed under 121.16—17. File Case 1.
Tracing.
Drainage.
18th St. Yard. For proposed plan "A."
Scale, 1 in. = 50 ft.
April 15, 1891.

It will be seen that the identification of the drawing from each of the cards is from the number of the first card, together with the scale and date. Cross-indexing, in this manner, is carried to any extent which seems desirable.

The cards used are 3 × 5 ins., medium weight, ruled. Colored cards are used to denote the physical characteristic of the drawing. White for tracings, survey notes and lithograph maps; blue for blue prints; salmon for negatives; buff for profiles, brown paper drawings, etc., and gray for black prints. In the index of drawings and surveys there are at present 2,500 cards, all of which are type-written. This comprises an index of all tracings and blue prints in the office, together with the surveys made during the last 10 years.

The classification of the cards in the cabinet is numerical in the following way: The cards are divided by hundreds, then by tens under each hundred. Below the tens the decimal takes precedence over the units of the number. This is to obviate dividing the cards pertaining to any one division of territory too many times, or (what is the same thing) to bring together under a few heads in the cabinet all the cards under each head pertaining to the same division of territory. For example, under 120 the arrangement is 121.12 to 127.12 in numerical order, then 121.13 to 127.13 in numerical order, and so on. When the drawing covers considerable territory, as 126.12-18 would indicate, the shorter drawings, as represented by the cards, precede the longer ones. When two or more cards have the same number, they are further arranged according to date of the drawing, the older preceding.

On guide cards through the index the main and minor divisions of subject matter of the decimal outline are printed, indicating the extent of cards on each of the subjects. Guide cards are cards having a portion of their length about ¼-in. higher than the remainder of the card. A number of divisions of territory are indicated on tab cards. Fig. 1 is a sketch of a guide card; Fig. 2 a tab card.

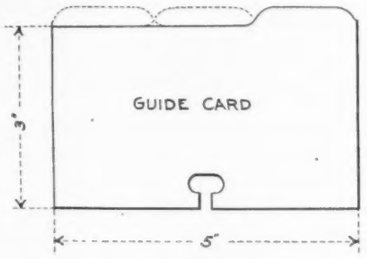


Fig. 1.

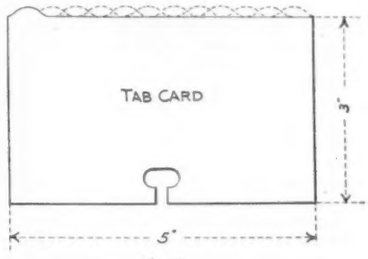


Fig. 2.

FIGS. 1 AND 2. CARDS USED IN CARD INDEX OF DRAWINGS; CHICAGO & WESTERN INDIANA R. R.

When a card covers more territory than indicated by a tab card, a duplicate of the first is made on a red card and inserted at the beginning of each division, as indicated by the tab cards, covered by the original card. For example, the following divisions of territory are indicated on tab cards in the index .12-.18, .18-.29, .31-.65, .71-.89. A card covering all of this territory would be duplicated in red after the first card and one inserted in each of the above divisions. In looking up any minor division of territory included in any of the above divisions the red cards in that division are looked over before looking for the particular division itself, in order to catch the cards which overlap the territory in question.

Through each tray of the cabinet there is a small split rod, which works in the slot of the cards represented in Fig. 1, and is operated by a milled-headed screw at the front of the tray on the outside. By turning this screw, all the cards are either locked or released, making it possible to take out any individual card with little inconvenience.

Aside from its use in indexing drawings, the card system is being used for the tabulation of various data pertaining to the road in the road-master's office. A record of all frogs and switches in the main tracks is tabulated and filed in the drafting room on cards of standard size, which were printed at a slight cost in the following form:

Div. ..... near ..... Track ..... Sta. No. .....
Length .... H. S. .... SWITCH. Style .....
Rail Sec... Rod spacing.. Style... Bolt spacing...centers
Drawing No.... Maker..... Splice bar drilling.....
Put in track..... Replaced..... In track.....
Remarks .....
FROG.
Number..... Lead.....
Rail Sec..... Heel.... Toe.... Total length.... Style....
Drawing No.... Maker..... Splice bar drilling.....
Put in track..... Replaced..... In track.....
Remarks .....

Both of the above forms are printed on the same card. Data in regard to each crossing on the road is tabulated on cards printed in the following form:

Div. ..... near ..... Track ..... Sta. No. .....
CROSSING.
Rail Sec..Central angle.. Intersecting line.. No. of Xing.
Drawing No.... Maker..... Splice bar drilling.....
Style .....
Put in track..... Replaced..... In track.....
Maintained by .....
Approximate wheelage per day.....
Remarks .....

These cards form an index by themselves, and are arranged by station numbers on each division of the road. Not only is the information thus collected in the most satisfactory form for reference, but the time required in tabulating and arranging in shape is reduced to a minimum. The cost of printing the cards is slight. Buff-colored cards were used for the data of turnouts, salmon-colored cards for the crossing data.

The card index is extended to include an index of the industries along the line. The cards are arranged alphabetically. The form of the data on the cards is as follows:

Willard Sons & Bell.
Founders.
98th St. (South Chicago Branch.)
1,000 lin. ft. track.

In fact, the uses of the index have developed to such an extent that the original 6-tray cabinet, with a capacity of about 4,000 cards, has been replaced by a 12-tray cabinet, with a capacity of 10,000 cards. Aside from its value as a time-saving device, the influence of the index system is felt in many ways. A general desire in the office for careful preparation, arrangement and filing of data and greater respect for the office and its efficiency is manifested. Once installed, the time required in keeping such a system up to date is not great.

For a permanent office the value of a card index system will not be over-estimated, and once installed it is safe to say that it will not be replaced by any other method of indexing. No office is too large and none too small for a card index.

The cards for the above described index were type-written, with the exception of those pertaining to the roadmaster's department. Owing to the amount of current work and the design of the type-writer available, the cards were written up outside on a private machine. Only a few makes of machines are capable of handling cards of the size and quality used without special attachments. The work was done on a Jewett, which is better adapted for such work than any other machine which was examined. Cards of a stiffness desirable for a cabinet do not work smoothly through a typewriter; they are not advanced uniformly with the roller, which necessitates having the cards ruled.

The greatest speed developed by amateur work was an average of 25 cards an hour. The lines being so short, it is doubtful if a professional could increase this number very much. In the above work ruled cards were used, on which the ruling did not agree with the spacing of lines by the typewriter. It is doubtful if any ruling would obviate the necessity of adjusting the card after each advancement of the roller. Cards of medium weight were used.

III. METHOD OF INDORSING AND FILING DRAWINGS.

Every drawing in the office, except where several are kept in the same roll, is indorsed on the back at each end with a legend descriptive of the drawing, with the scale and date of same arranged as shown in Fig. 3 at about full size. A standard size and arrangement is used for this indorsement. If the draftsman's table is covered with detail paper, a form ruled upon it is convenient, over which a tracing may be placed for indorsement. On long drawings the indorsement at each end is made to read in the direction the drawing would be unrolled from the end in question. Thus a profile covering the territory from Chicago to Hammond would at the Hammond end read Hammond to Chicago, and at the other end read Chicago to Hammond. This is desirable with long drawings.

Indorsement of drawings on the back applies to drawings kept rolled. The drawings of this office are kept in that manner. Even though the file number identifies the drawing for filing purposes, still a further description with the scale and date of the drawing saves a great deal of time and patience. The process of identifying a

tracing by the size of the roll or by the tint of the cloth is hardly a satisfactory method.

In railway offices most drawings are longer than any length which could be adopted for a standard size. Standard sizes are more suitable for shop drawings, which are usually filed flat. The drawings under discussion are kept in rolls. Where drawings are kept in this manner especially the question arises of keeping them from becoming filthy by the accumulation of dust and dirt. Railway offices are often surrounded by more or less smoke and soot, especially in large cities. The most common file for drawings is the pigeon hole and drawer. Dust will accumulate in each. The office under discussion is situated in a room opening almost directly off of the trainshed of the terminal station. There is no vault in connection with the office. The accumulation of dust and dirt in the pigeon holes and drawers was considered to be unbearable in the use of the more important drawings. To overcome this condition, pasteboard tubes about 1¼ ins. diameter and 32 ins. long (the depth of the filing case) were adopted. The tubes are made with one end closed, over which is pasted a circular disk of white paper of a diameter about ⅛-in. less than the diameter of the tube, to prevent the scuffing of the edges as the tube is inserted and withdrawn from the files. Drawings filed in these tubes have their index number, scale and date on the end of the tube for identification in the files. Fig. 4 represents at full size a sample indorsement. The size of the pigeon holes is 6 × 6 × 32 ins., with a capacity of 16 tubes of the above size. The indorsed ends of the tubes are flush with the face of the filing case, and give it a neat appearance. The back of the case acts as a cap to the open ends of the tubes, which are thus made practically dustproof while in the files. After six months' service a drawing thus filed can be drawn through one's hand, leaving no sign of dust upon it.

121.16-17 PROPOSED EXTENSION OF 18TH ST YARD. PLAN "A".
SCALE 1"=50'.
APR. 15, 1891.

Fig. 3.

121.16-17
EXT'N 18TH ST. YD.
SCALE 1"=50'.
APR. 15, 1891.

Fig. 4.

FIGS. 3 AND 4. FORMS FOR INDORSEMENT OF DRAWINGS AND TUBES.

The cost of the tubes was about 1⅞ cts. apiece for 1½-in. tubes, and about 1¾ cts. for the 1¼-in. tubes. Most drawings are easily inserted in the smaller size. Nothing but tracings, and only the more important of these, are filed in this manner.

There are two filing cases in the office, the first equipped with tubes as described above, the second with plain pigeon holes, which contain a large accumulation of old drawings and records. Drawings are arranged in the cases similarly to the arrangement of the card index, according to territory divisions under the minor divisions of subject matter. Very large rolls and drawings too long for the filing cases are filed in drawers. The use of two filing cases and the drawers tend to scatter drawings. The drawers are unavoidable, being necessary for long rolls. However, a considerable amount of handling of old drawings, which would be necessary were all the drawings thrown together, is avoided by the use of the two filing cases.

Each drawing, aside from its indorsement, above described, is identified with its drawer or filing case by being stamped on the back at each end near the indorsement: "FILE CASE 1," or "DRAWER 13," for example. The same identification is stamped on the card corresponding in the card index for each drawing. The card index then, will always tell where a drawing is to be found, no matter how obscure its place. The drawings are by this means also identified with their places in the files. The cards are stamped in the upper right hand corner on the same line as the index number.

A stenographer's note-book is kept hanging in a convenient place in the drafting room, in which new drawings are entered and from which the cards corresponding are written. The drawings are then kept by themselves in a drawer without filing in their proper places until the cards are written, which is done at odd times. When written the cards and the drawings are compared and each stamped with the place of filing the drawing. By this method the stamp on the drawing indicates that the card has been inserted in the card index and vice versa.

The cards are not divided according to the place of filing the drawings, but are all kept together. By the use of the card index a person is never at a loss to know where to look for a drawing. Blue prints of current work are indorsed, but are not card indexed until they become a matter of record. They are kept separate from the drawings which are card indexed.

IV. INDEX OF SURVEY NOTES.

The index of survey notes includes all the surveys of the last ten years, contained in about 50 field books. A card is written for each survey recorded during that time in the following form:

213.26—29. Survey. Bk. 27, p. 1—8.
Levels.
47th to 72d St. Top of rail No. 1 track.
January 16, 1893.

Survey notes come under 200 of the decimal outline. Each card is given a number, in a manner similar to that used for indexing drawings. The cards are filed by territory primarily, then in numerical order for each division of territory, and then chronologically when two or more cards have the same number. By this method all the surveys for any division of territory are bunched together in the index and can be quickly run over for the subject matter desired. From time to time the index is kept up to date by entering a description of the new surveys in a note-book in the same manner as described for drawings. As fast as the cards are written they are checked off in the field books by stamping the word "INDEXED" in small type at the bottom of each page covered by the card. The field books thus show at any time what surveys are covered by cards. Each book is indexed in the ordinary manner on the first few pages of the book. With the file of books is kept a tabulated list of the books in numerical order, giving in a general way the contents of each book. This is for convenience in referring to books given up entirely to a single survey without going to the card index. In the card index the divisions of territory are combined into groups indicated by tab cards, as described for drawings. A card for a survey covering more than one group is duplicated in red for each group covered and one inserted at the first of each group. In looking for a survey for any particular division of territory the red cards in the group under which the division of territory comes are looked over to catch any extended survey covering the territory in question.

This index of surveys has been installed a year. It is considered indispensable. It saves time and puts a large amount of information within easy reach. It also brings in information needed in many cases, but which would not be looked up, even though it was known to be in the office, because of the time required and the disagreeable work of looking through a lot of dusty field books. With this method of indexing, the office boy can bring to light almost any survey desired. It is especially gratifying to be able to produce on short notice all available data for any part of the line and to know when all has been produced.

At the present time there is considerable attention being given to the subject of indexing. Many engineers are turning from the book index to the card system of indexing, as being more elastic and substantial. References on the subject of indexing, giving details of systems in use in such a way that one may profit by the experience of another, are rare. The only articles known to the writer bearing on the subject in any way are the following:

Report of Committee on Office Management; Connecticut Civil Engineer and Surveyors' Association Report, 1900.

Library Journal, Vol. 20, p. 199: "Care of Maps in Naval Observatory, Washington, D. C."

Library Journal, Vol. 25, p. 15: "Preservation and Record of Maps in Library of Congress," by P. Lee Phillips.

DUST IN BLAST-FURNACE GASES.*

By Adolphe Greiner.†

The present paper is a sequel to the communications I have had the honor of presenting to this Institute on certain former occasions—in particular, the May meetings of 1898 and 1900. Its object is to complete the information which may be found useful to all persons interested in the employment of blast-furnace gas in gas engines. From another more personal standpoint, it will serve to acquit me from the undeserved reproach of having incorrectly stated that gas engines on the Cockerill-Delamare plan could utilize raw, impurified blast-furnace gas.

To begin with, I wish to remark that my former communications have never had any other basis than facts—proved in each case, and were not founded on more or less hazardous speculation.

In saying as I did at last year's spring meeting, that we had at Seraing a 200-HP. engine, driving an electric motor since April, 1898, without the cylinder having been once cleaned, I simply enunciated a positive fact, and I may add that now, after three years' continuous work, the engine runs day and night without having had to be stopped even once for the purpose of cleaning the cylinder. Experience showed us later on the cause of this result, with which I shall deal presently.

On the other hand, the 600 I. HP. gas-blowing engine of a similar type to the one exhibited last year in Paris,‡ did not meet with any difficulty in working, and my last communication of May 9, 1900, was simply a statement of practical results obtained at our works.

We had hardly started, however, in August, 1900, with the first of nine 600-HP. engines at Differdingen (Luxemburg), than, after three weeks' running, we experienced the fatal results of the excessive quantity of dust contained in the blast-furnace gases at these works. We were thus led to examine the amount of solid matter impregnating the gas, and to our astonishment found at Differdingen from 4 to 5 grams per cubic meter, while similar researches made subsequently at Seraing did not reveal the presence of more than from 0.25 to 0.50 grams in the gases from our own furnaces, or, say, ten times less than at Differdingen. The cleansing of the gas thus became a necessity, and we shall see further on how an absolutely perfect and extremely simple solution of the problem was discovered. We were thus led to look more closely into the nature of the gases outside Seraing, and results were ascertained by our chemist in eight or ten establishments where he was allowed to analyze the blast-furnace gases for dust.

The first remark called forth by these results is that the degree of pureness of blast-furnace gases varies greatly with different works, and this is easily to be understood, from the different natures of the ores smelted Generally speaking, the gases are purer in works producing hematite pig irons from hard ores in lumps, or mixed with purple ores, when, as is the case at Seraing, the dust from these last (always rather heavy) is deposited in the pipes and chambers nearest the blast furnaces, and is not carried any very great distance. On the contrary, the gases contain large quantities of fine dust in works which deal with oolitic ores, whose impurities consist mainly of a kind of clay which the heat causes to dry, and which the gaseous current carries to great distances—such being the case at Differdingen, and in general throughout the Luxemburg district.

A second important remark is the following: It is a mistake to suppose that the dust can be efficiently separated by depositing in long passages, vertical pipe arrangements or chambers of large capacity. The dust is often reduced to such a state of tenuity that the gas continues to carry it in spite of all checks of the kind referred to, and the clouds of white smoke issuing from the tops of high chimneys prove that the gas after traveling hundreds of yards still contain appreciable masses of light solid matter.

I will now proceed to describe how the cleansing of the gas was accomplished at Differdingen. A choice had to be made between two methods. The first, which may be termed the "static" method, consists in the use of a series of scrubbers or sheet-iron towers containing coke or sawdust, cooled by a spray of water, which plant, first introduced by Mr. Thwaite, is in use in England, and also under different forms

*A paper read before the Iron and Steel Institute of Great Britain.
†Societe John Cockerill, Seraing, Belgium.
‡Eng. News, July 19, 1900.

at the Oberhausen blast furnaces in Germany, at Differdelingen in the Grand Duchy of Luxemburg and elsewhere. This method is somewhat cumbersome and costly to put down, requiring the use of an aspirating fan or exhauster, but it gives perfect results as regards cleaning.

The second method, which we should name the "dynamic" one, is based upon a reaction due to centrifugal force provoked between the gaseous mixture and a spray of water injected into a suitable apparatus. The liquid and solid particles thrown against the periphery of the apparatus are expelled by an opening in the envelope, while the gases which have been mixed and agitated by the action of rotating blades, escape through the exhaust orifice in a perfectly purified condition. Different analyses made at Horde on gases treated by M. Theisen's apparatus leave no doubt as to this result, the quality of dust per cubic meter of gas being sometimes reduced to less than 0.01 gram.

At Differdingen the principle of "dynamic" cleansing has been very simply carried out by using an ordinary centrifugal fan, 1.50 m. in diameter, running at a speed of 900 revolutions per minute, through which the whole of the gases are passed, being drawn in by the central apertures. Water is supplied by a pipe 26 mms. in diameter, opening into the axial part of the fan. The gas alone is driven out by the fan discharge, the water, charged with dust, being led off by a pipe 50 mms. in diameter from the lower part of the fan casing.

The gases which, before being brought into the fan, contained 4 grams of dust per cubic meter, leave it containing only 0.25 gram, and are in a proper condition for use in a gas engine without further treatment.

The quantity of water required is very small, and varies with the degree of cleanliness to be obtained. With 10,000 liters of water per hour, the dust in 10,000 cubic meters of gas can be reduced to 0.30 gram per cubic meter, and with 15,000 liters to 0.20 gram, or, say, 1 to 1½ liter of water per cubic meter of gas.

The apparatus takes up little room, and is by no means costly. For an outlay of 10,000 francs ($2,000) the gas can be cleaned for six 600-HP. engines.

Mr. Meier, the general manager of the Differdingen Works, intends to carry out more completely the cleansing operations, by sending the gases leaving a first fan through a second one; experience can alone decide whether this improvement is necessary.

It may be of interest to point out that the "dynamic" method of cleaning possesses the advantage over the ordinary one of supplying the gas at a certain pressure (from 20 to 25 centimeters water-gage), by which it becomes possible to carry it in sufficient quanity through pipes of comparatively small diameter, and thus reduce the first cost.

In conclusion, facts have shown that the cleansing of blast-furnace gas can be effected by simple and economical means. No reason exists why the principle should not be carried further and the gases be cleaned before use in the blast-heating stoves or boiler flues. I venture to call the attention of all blast-furnace owners to the immense economy to be realized by this process, which constitutes a new advance in furnace management—so true is it that progress in one direction always calls forth concomitant results in another.

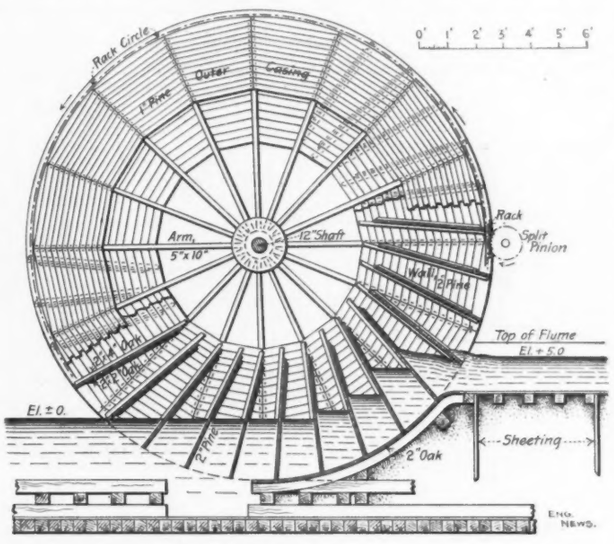
THE WHEEL-PUMP FOR LIFTING SEWAGE AND STORM WATER.

For low lifts, such as are often required for disposing of sewage or storm water, the wheel-pump described by Mr. Ossian Guthrie, in the Journal of the Western Society of Engineers for February, 1901, seems to have advantages in economy of construction and operation, in capacity and in elasticity of output. It may be briefly described as an old-fashioned breast water-wheel to which power is applied to drive it backwards.

Mr. Guthrie says that his father, Mr. Alfred Guthrie, constructed two wheel-pumps in 1848 for supplying the Illinois & Michigan Canal from the river, and these pumps were in use until 1871. One of these wheels was 32 ft. in diameter, with a 7-ft. face, in the clear, dipping 4.5 ft. into the river. This wheel-pump gave no trouble until 1859, when some of the wood began to decay. In 1859-60 two new wheels were built, 38 ft. in diameter and 10-ft. face; there were 32 buckets and the middle support was a set of arms and a rim to which the bucket supports were attached. These wheels were operated by double engines, with cranks set at right angles, and having 8 tons of flywheel in a rim 16 ft. in diameter. The pumping wheels had a rim travel of from 100 to 400 ft. per minute, showing maximum efficiency at about 250 ft. The range in dip, caused by the fluctuations of the river, was from 5 to 9 ft., and caused no inconvenience.

As described, these wheels were built of the best material and with the greatest care. They were lined inside, about 10 ft. from rim, toward the center, with planed and matched planks; and sheathed on the outside with similar material, so that they presented a smooth and even surface to the water. The buckets were set at an angle of about 20° from the radial line.

The rim of the wheel was carefully turned; and the concave in which the wheel moved was as carefully finished. This concave was made adjustable on a horizontal line, and the wheel on a vertical line, so as to permit of close adjustment. Around the rim a heavy sole leather strip was fastened, which served as packing. The concave extended from a point directly under the shaft to a point below the surface of the upper level, where the most perfect discharge could be secured—a distance of little less than the distance between the buckets.



SECTION OF WOODEN WHEEL PUMP FOR LOW LIFTS.

Mr. Guthrie says that pumps of this type will pass rubbish, chunks of wood, etc., with ease; if the dip increases from, say, 5 to 10 ft., the wheel goes on, but delivers nearly double the amount of water; or it will give an increased quantity with decreased lift. If there is a demand for greater output, the speed can be increased. The design of these pumps is based on the crude wheel-pumps long used in Holland and in Italy. The two wheels built by Mr. Guthrie in 1860 easily lifted 25,000 cu. ft. of water per minute through a distance varying from 5 to 10 ft.; and including the building the cost of these pumps was $45,000. At the end of 12 years they were rebuilt and enlarged at a cost of $55,000. Mr. Guthrie believes that for situations calling for a large volume of water and a low lift these pumps are 50% cheaper than a centrifugal pumping plant, in first cost, and will save from 10 to 25% in maintenance.

GAGINGS OF DRY WEATHER SEWAGE FLOW AT TORONTO, ONT., IN 1900.*

By Cecil B. Smith, M. Can. Soc. C. E.

During March, April and May, 1891, the discharge of sewage from Toronto sewers was measured by Mr. C. H. Rust, M. Can. Soc. C. E., then engineer of sewers, and the results placed before the society in January, 1893 (paper 71).† Since that time the city has taken up the question of sewage disposal in a cursory manner only. Nothing but preliminary work has been yet entered into, which has roughly consisted of levels and projects for various trunk sewers, etc., made at various times in past years, and recently cross-sections for filter beds and the measurement of the dry weather flow of sewage, which were carried out by the writer during the winter of 1899-1900.

The determination of the dry weather flow of sewage was made with a view of confirming previous records, amplifying them, and establishing recent, accurate data on which to base the designs for interceptors, trunk sewers, and disposal works. The gaging was undertaken with considerable care, and carried out as accurately as possible; the weirs which had been previously used were reconstructed, or repaired, others made, and, to insure accuracy, a steel edge was added to the crest of the rectangular weirs in thin partition, the weir-depths being taken by hook gage.

The setting and checking of weirs and recording of depths were in direct charge of G. F. Hanning, Assoc. M. Can. Soc. C. E., while the work was done by four of the most trusted and careful employees of the sewer department, and it can be relied on for accuracy.

The records were taken, at each sewer at each hour of the day and night for five or six days, but only during periods when there was no rain or thaw. The work extended from Jan. 9 to March 13, 1900.

The method of procedure was briefly as follows:

Weirs were placed just at the upper sides of the manholes, wedged against struts and carefully puddled, platforms were built in the manholes from which to take observations, after which the hook gages were fixed about 2 ft. up stream from the weirs, and adjusted in a slot or groove alongside a scale graduated to ⅛-in. The zero of the scale and the arrow on the hook gage arm coincided when the point of the hook was level with the crest of the weir. The weir-depths could thus be taken off by inspection, which lessened any chance of error. A lantern was suspended in the sewer and a little practice enabled the readings to be taken with great accuracy, as proven by frequent check readings taken by Mr. Hanning and the writer.

Before commencing computations, it was seen to be easier to draw up a table of discharges for various widths and depths to work from, and this was done; this table is appended hereto (not reproduced.—Ed.) because it can be applied to any width of weir by using fixed increments, and may therefore be of use to members of the society. Several authorities were consulted, but the Francis formula, with end contractions, was adopted as being probably most accurate (see table of discharges for the formula) and in using the table as prepared, a correction for velocity of approach was made by the proper increase in depth of water over the crest of weir, for each sewer and depth. The results (see table)‡ show that since 1891, the dry weather flow of sewage has increased as follows:

	Imperial gallons per day for—	
	1891.	1900.
Gross dry weather flow	13,421,622	20,745,734
Net dry weather flow	12,972,344	19,847,551
Water pumped	14,976,000	21,786,500

The net flow is less than the gross flow by the amount of sewage or water received by the city sewers from other municipalities, which amount was gaged in 1900 and estimated for 1891. At these same periods the average water pumped by the Toronto water-works was as shown above.

This indicates that the same conditions prevail now as in 1891 (i. e.), that either the pumping records are in error (which is not likely), or else that there is 2,000,000 gallons or over per day of water pumped which does not reach the sewers, being in various ways evaporated, etc., and that there is therefore no great amount of ground water entering the sewers during the winter months.

The pumping records are furnished through the kindness of Mr. C. L. Fellowes, Deputy City Engineer, and the quantities are based on accurate tests made in 1898, allowance being made for slippage.

Whether this allowance was sufficient or not is perhaps a debatable point.

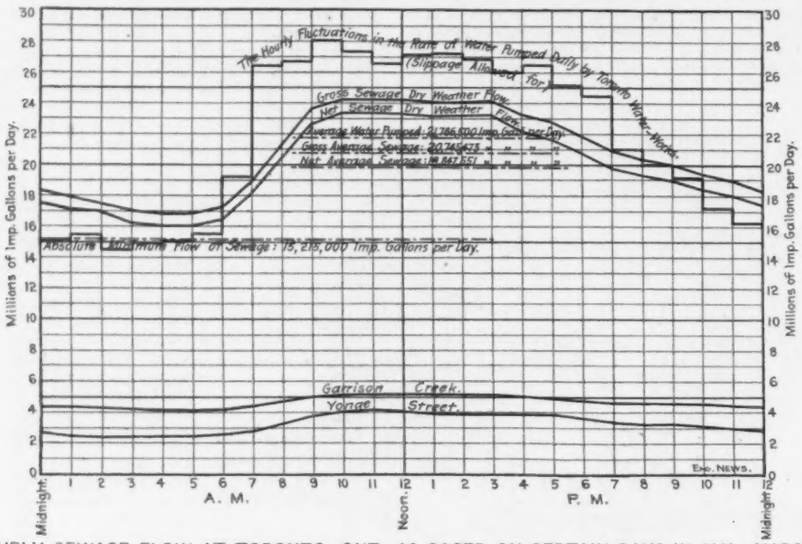
The total area sewered is approximately 7,426 acres. The population of the city was (1899) by assessment rolls, 192,162, which, judging by previous records, should be increased 13% to give the actual population, or say 217,100, which gives corresponding populations per acre of 25.4 by assessment rolls, and 28.7 by estimated population, although this varies from 9.2 per acre to 54.3 per acre on

*Slightly condensed from a paper read before the Canadian Society of Civil Engineers.

†The results were also published in the report of the city engineer of Toronto for 1891, and a summary of them was reprinted in Engineering News for Nov. 24, 1892.—Ed.

‡In the original paper, the average results are given by hours for each sewer. The hourly fluctuations are represented in the consolidated curves, reproduced herewith, while on the same diagram the hourly gagings for two sewers are given.—Ed.

different sewer areas. The daily average flow per acre is 2,794 Imperial gallons, varying from 890 to 7,439 Imperial gallons in different districts. The sewage per head per day varies from 49½ Imperial gallons in a thinly populated residential district, to 724 Imperial gallons in a manufacturing and office building district, but averages 105.2 Imperial gallons, based on assessment rolls, and 93.1 gallons, based on estimated population. It is noticeable that all those small sewer systems, like Bay St., Front St., Eastern Ave., W., and Berkeley St., which are in business districts, have large flows per head per day, owing to the small resident population, and to the liberal use of water for elevator work, and manufacturing. The next largest flows per head per day, are on the Yonge, Church, Jarvis and Bathurst districts, all over 100 gallons per head per day.


The Hourly Fluctuations in the Rate of Water Pumped Daily by Toronto Water Works.
(Slippage Allowed For.)
Gross Sewage Dry Weather Flow.
Net Sewage Dry Weather Flow.
Average Water Pumped: 24,786,600 Imp. Gals. per Day.
Gross Average Sewage: 20,745,473 " " "
Net Average Sewage: 19,847,551 " " "
Absolute Minimum Flow of Sewage: 15,215,000 Imp. Gallons per Day.
Garrison Creek.
Yonge Street.
Millions of Imp. Gallons per Day.
Eng. News.
Midnight. 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 Midnight.
A. M. Noon. P. M.

HOURLY SEWAGE FLOW AT TORONTO, ONT., AS GAGED ON CERTAIN DAYS IN JAN.—MARCH, 1900.

(This is a consolidated diagram for the various sewers of the city, with the results for two of the sewers and the hourly water pumpage added.)

These district are partly business and partly residential, and being in the older portions of the city, have, perhaps, more than their share of leaky water fixtures, defective plumbing, etc. The remainder of the sewers mostly run at 80 to 90 gallons per head per day (as we must deduct county water from Rosedale and Garrison Creek sewers, making them each 90 gallons) based on assessment population, or say 70 to 80 gallons per day for an estimated total population of 217,000.

Various calculations may be made for each sewer to show how long it would take for ¼, ⅛, ⅛, etc., of the daily flow to arrive at the outlets, but one calculation for the whole city will serve as an illustration. It will take to arrive at the outlets of all the sewers of the city:

5½ hrs. for ¼ of the total daily sewage;
6.9 " " ⅛ " " " "
10.6 " " ½ " " " "

A study of the curves of flow for each main sewer, and the curves of gross and net dry weather flow for the whole city along with the diagram of pumping records will bring out two points very sharply. (Only the consolidated curves are reproduced.—Ed.):

1. That although the flow of sewage is, of course, 25 to 100% greater during the day than in the night, yet the flow during the "wee sma'" hours is very great, and making same allowance for ponding of sewage during the day, in sewers with solids deposited on the inverts, which ponding would all get away soon after midnight, we have the bald fact that from 1 to 5 a.m., the flow of sewage is at the rate of 15,000,000 to 16,000,000 gallons per day, with, as before stated, no probability of any great amount of ground water to draw from.

2. If we take the sewage flow and compare it with the pumping records from 1 to 5 a.m., the cause of this flow is evident; for, with reservoir closed off, the pumping during these hours was at the rate of over 15,000,000 gallons per day in order to keep up the pressure in the mains.

Now the writer does not desire to specifically point a moral or adorn a tale by trying to dwell at length on the subject of water waste prevention, as Toronto is no worse a sinner in this respect than are most cities of this continent, but it would appear that as there is very little water used in the middle of the night, some 12,000,000 to 15,000,000 Imperial gallons per day must be going to waste somewhere. Most likely the loss is caused largely by the innumerable leaks, bad plumbing, etc., of inferior fixtures and services. If this is the case, we must look toward proper plumbing laws, with proper legal enforcement, rigid, incessant inspection and supervision of the installation and repairs of plumbing work, and the throwing of the burden on the tenant and landlord both as the means for reducing the consumption to something in the neighborhood of 30 to 40 Imperial gallons per head per day, which represents good practice in Great Britain, a country inhabited by a clean, industrious, and industrial people, and what is enough for them should suffice us here.

This subject of water waste prevention is always important, but particularly so, now that the day is fast approaching when the treatment and disposal of the Toronto sewage and that of many other Canadian cities and towns must become a subject to be grappled with and solved, and then it will be doubly essential that the amount of sewage to be treated shall be kept down to as small an amount as possible, as the treatment of 20,000,000 gallons per day of even diluted sewage is a problem, the magnitude of which only the initiated are likely to appreciate. At present, there are only a few sewage disposal plants of such a size; and none of such a size, either of the septic tank or contact bed types, and it is probable that bacteriological treatment will be the method adopted, when the question is finally taken up for solution in Toronto, unless it is delivered in a crude form at a distance from the city into the deep water of Lake Ontario.

CHAINS AND CHAIN GEARING.*

By Charles Piez.

Chains have so well established a place in the mechanical world as a means for transmitting power that it is necessary to say but a few words concerning their scope. They are applicable wherever a positive speed ratio is to be secured, wherever heavy strains at low speeds are to be transmitted, wherever a damp or hot atmosphere would prove destructive to belts or ropes, and wherever power is to be transmitted without sacrificing the flexibility of the shaft supports, as in the case of agricultural machinery.

Just as gears may be roughly classed as cut and cast, so chains can be grouped as machine-made and cast. The former have been almost solely applied to bicycles and motor cars, while the latter are applied to elevating, conveying and the transmission of power in the mechanical arts. The limitation to the use of machine-made chain is almost wholly a matter of price, and is due very largely to the fact that its manufacture has never been so systematically organized as to produce a well-made chain and sprocket wheel at a reasonable price. Machine-made chains, when properly designed and well made, are stronger, more durable and less noisy than cast chains of equivalent bearing surface and section. But owing to their lower first cost, the latter have been much more extensively used.

I described machine-made and cast chains as resembling cut and cast gears in their classification; I might carry the simile further by stating that there is as much difference in cast chains as there is between well-made machine-molded gears and gears cast from carelessly made patterns. That chains shall run properly with their wheels, it is essential that the links shall be accurate as to pitch, that the pintels shall bear uniformly in their seats, that the wheels shall be of the proper pitch diameter, the teeth of proper pitch and shape, and that the bearing and sprocket surface shall be proportionate to the strains to be transmitted. The last requirement is one that can be overcome by proper design, but those who are familiar with the "vagaries" of castings can imagine how difficult is the realization of the other four requirements. The high-class Ewart malleable chains are subjected to 17 distinct operations after removal from the annealing pots, and while primarily cast chains, they are, by selection, by treatment and by testing, brought to an accuracy and uniformity which leaves but little to be desired.

The wear on chains is twofold, internal and external. The internal wear is due to the articulation of the links, and takes place between the pintel, or what in Ewart chains is termed the end-bar, and its bearing. The external wear is that which is caused by the engagement of the link with the sprocket.

Lubrication of both the chain bearings and the teeth

*A paper read before the Engineers' Club of Philadelphia.

Dry Weather Sewage Flow at Toronto, Ont., Reported in Imperial Gallons.*

Location.	Sewer Size.	Fall.	Width of weir.	Drainage area Acres.	Population 1899. Total.	Pr acre	Average daily flow of sewage, Imperial gallons. No. days average	Total.	Per head.	Per acre.	Capacity sewer Running full.	Dry flow.
Fort Rouille	2' 6"×3' 9"	1/200	14 ins.	330	3,593	10.9	5	306,544	85.3	929	18,630,000	1/61
Dufferin St.	2' 6"×3' 9"	1/80	14 "	357	6,781	19.0	5	577,422	85.2	1,618	42,604,000	1/74
Garrison Creek	80" circlr.	1/384	50 "	2,112	45,792	21.7	5	4,686,494	102.4	2,219	217,467,000	1/46
Bathurst St.	2' 6"×3' 9"	1/80	14 "	223	9,158	42.6	5	921,548	100.6	4,291	39,970,000	1/44
Spadina Ave.	3' 8"×5' 6"	1/80	22 "	390	16,534	47.8	5	1,456,494	88.1	4,213	95,276,000	1/65
Simcoe St.	43" circlr.	1/173	30 "	600	16,438	28.4	5	1,575,052	95.8	2,721	61,236,000	1/39
Bay St.	2' 0"×3' 0"	1/118	14 "	29	280	9.7	9	202,632	724	6,987	15,480,000	1/76
Yonge St.	3' 6"×5' 0"	1/289	30 "	565	18,426	32.6	9	3,302,088	179.2	5,844	45,864,000	1/14
Church St.	2' 8"×4' 0"	1/100	18 "	160	6,492	40.6	6	880,122	135.6	5,500	37,800,000	1/43
Jarvis St.	3' 6"×5' 0"	1/118	30 "	144	7,221	50.1	6	989,069	137	6,868	62,838,000	1/64
Sherbourne St.	2' 6"×3' 9"	1/200	18 "	115	4,051	35.2	5	369,296	91.1	3,211	44,100,000	1/119
Berkeley St.	2' 0"×3' 0"	1/115	14 "	43	1,757	40.9	5	367,616	209.2	8,549	15,687,000	1/42
Parliament St.	3' 6"×5' 0"	1/346	30 "	240	13,049	54.3	5	1,258,499	96.4	5,243	45,144,000	1/36
Cherry St.	2' 8"×4' 0"	1/200	18 "	243	11,997	49.3	5	1,067,592	89	4,394	21,906,000	1/20
Front St.	2' 0"×3' 0"	1/388	14 "	31	702	22.6	5	230,627	328.5	7,439	6,948,000	1/30
Eastern Ave. (W.)	1' 2"×1' 9"	1/200	7 "	205	333	16.2	5	68,249	204.9	3,329	2,736,000	1/40
River St.	2' 0"×3' 0"	1/133	14 "	42	2,217	52.8	5	115,688	52.2	2,754	14,346,000	1/124
Rosedale Creek	66" circlr.	1/400	40 "	758	8,064	10.7	5	1,052,952	130.5	1,389	116,469,000	1/110
Eastern Ave. (E.)	2' 0"×3' 0"	1/133	14 "	44	934	21.2	5	76,406	81.8	1,736	9,171,000	1/124
Blong Ave.	16" circlr.	1/400	7 "	137	220	16.0	5	12,898	58.6	941	2,910,000	1/225
Logan Ave.	16" circlr.	1/333	7 "	15	418	27.9	5	20,695	49.5	1,380	3,207,000	1/155
Carlaw Ave.	16" circlr.	1/400	7 "	224	480	21.4	5	29,633	61.7	1,323	2,910,000	1/98
Morse St.	16" circlr.	1/295	7 "	127	365	28.7	5	43,430	119	3,419	3,486,000	1/80
Leslie St.	2' 4"×3' 6"	1/165	30 "	906	9,812	10.8	5	807,449	82.3	891	7,650,000	1/9
Lake St.	2' 4"×3' 6"	1/280	14 "	10	92	9.2	5	8,900	96.7	890	16,290,000	1/1810
Total								20,427,395				
Unmeasrd sewage..					3,471			318,078				
Gross total				7,426.3	188,643	25.4		20,745,473	109.9	2,794		
Population: Unsewered					3,519							
Total, ass'd '99.					192,162							
Deduct Contributions from West Toronto Junction and from County.												
W. Toronto Junc..			14 ins.				3	489,239				
Ossington Ave.			22 "		45,792		3	65,424	12.6			
Garrison Creek			30 "				3	20,553				
Rosedale Creek			40 "		8,064		3	322,706	40			
Total								897,922				
Net total				7,426.3	188,643	25.4		19,847,551	105.2	2,673		

*The gagings on the various sewers, generally five days to each, were made from Jan. 9 to March 13, 1900. The results were calculated by Francis' formula,

$$Q \text{ (in gallons per minute)} = 2.4953 \left\{ L - \frac{1}{10} n d \right\} D^{\frac{3}{2}},$$

(with an allowance for velocity of approach); in which L = width of weir; d = depth of water flowing over weir, and n = number of end contractions.

of the wheels would largely reduce both kinds of wear, and in the larger chains used for dredges, special provision for properly lubricating the chain bearings is made. But these provisions are applicable only to very large chains, and even were they not so limited, the cost of such devices when applied to the smaller chains would stand in the way of their general adoption. Every chain, no matter what its duty or what the atmosphere it runs in, should be lubricated at frequent intervals. The joints should be wiped free from dust and sticky oil, and an effort should be made to get the lubricant into the bearing. Besides this, the teeth of the wheels should be cleaned and a heavy grease applied to them. In a large percentage of cases, when a chain gives trouble, such a treatment will give relief.

But the chain manufacturer realizes that the lubrication of chains is not always an easy matter, and his aim has therefore been to produce a chain joint which would prove durable in spite of imperfect lubrication. Two general methods have been employed to achieve this result. The first method consists in the use of a rocking joint, which is an application of the knife-edge principle to the chain bearing. This application was the subject of a generic patent granted Mr. James M. Dodge, on July 13, 1880. Only a fractional part of a complete revolution is possible with this form of joint; but by limiting the number of teeth of the smallest wheel to be used, the arc of articulation can be brought within the practicable limits of the rocking joint. This joint is practically free from friction, even without a lubricant; and when the force to be transmitted lies well within the safe limits of the strength of the bearing edge, it gives excellent results in practice. The Morse bicycle chain and the malleable iron rocker-joint chains are examples.

The second method to obtain a durable joint consists in hardening the surfaces in contact. In cast or malleable iron chains this is accomplished by using case-hardened steel pins bearing against bushes of hard metal. In the chain invented by Mr. Francis Ley, of Derby, England, this principle is carried one step further. The cast frame is cut away so that the outer surface of the case-hardened bush bears against the wheel. Both the external and internal wear in this chain is therefore concentrated on case-hardened parts, and these parts are made so that they can be renewed when worn.

As the external wear is wholly due to the action of the wheel on the chain, it will be necessary to give a brief description of the action of the chain on the wheel and the rules which should govern a proper wheel design. The popular notion is that when a chain gears into a toothed wheel all the teeth entering the chain are simultaneously in action. This is not true, for no matter how accurately a chain and wheel may fit when new, the moment a strain is brought to bear on the chain, and the wheel begins to turn, the pins begin to bed themselves into their bearings, producing at once a lengthening of the pitch. The amount of this bedding or seating may be infinitesimal in each joint, but it is sufficient to destroy the simultaneous bearing on all teeth. The action between chain and wheel tends to wear the chain long and the wheel small, and results in one tooth doing all of the work at one time.

The accompanying cuts will illustrate the principle of chain gearing with the ordinary types of chain:

Fig. 1 shows a wheel with a chain fitting every tooth. This is an ideal condition that may exist before the gearing has been put into operation and when the chain and wheels have been made with extreme accuracy. But this condition ceases as soon as the chain runs long enough to bring the joints to a bearing. Then the chain approximates the position on the wheel shown in Fig. 2, which represents the wheel shown in Fig. 1, when gearing with a chain slightly worn.

The link A is now the only one which is in working contact with its tooth, the reason being that the chain has lengthened, whereas the wheel has remained the same. As the wheel turns beyond the position shown in the figure, link G wedges itself into position and crowds out link A, throwing the latter into about the position shown by link B in Fig. 2. The work is therefore done by one tooth, and that, too, during the period when the tooth is acting like a wedge to prevent the seating of the link. Only a portion of the power, therefore, is usefully employed.

Fig. 3 represents the third stage of the same wheel, viz.: when gearing with a worn chain. In this instance the defects of the last case have become aggravated and the working of the chain becomes irregular, the links frequently jumping the teeth. The construction shown in the foregoing results in a waste of power, a rapid wear of the chain and an irregular and jerky motion.

In Fig. 4 is shown the correct construction of the driving wheel, and this figure shows it gearing with a new chain. As will be seen, the wheel pitch is longer than the chain pitch, and the tooth space is much wider than the accommodation of the chain joint would require. This construction brings the driving tooth at the outgoing end of the chain instead of the incoming end.

Fig. 5 shows the same driver gearing with a slightly worn chain. The driving is still done by the tooth engaged with the outgoing link, but links B, C, D, E and F have moved closer to their teeth without touching them.

Fig. 6 shows the correctly constructed driver gearing with a much worn chain, and in this case the conditions, after a long and useful life, approximate those of the new chain when gearing with an incorrectly constructed driver, as shown in Fig. 1. To secure the proper operation of the chain, the driving face of the tooth should be so curved as to permit the outgoing link to readily free itself. The release must at the same time be gradual, so that the following link will slip back into engagement with the sprocket without jar. The proper design of the tooth face is shown in Fig. 7, which shows the first stage of the outgoing chain.

As the foregoing cuts have shown the advantage of making the driver wheel longer in pitch than the chain, so the two following cuts will point out the advantage of making the driven wheel slightly shorter in pitch than the chain. In practice the chain and wheel pitch are made alike, because the lengthening of the chain as soon as it is set to work produces at once the desired effect.

Fig. 8 shows the correct driven wheel gearing with a new chain, and Fig. 9 shows the same wheel gearing with a worn chain. It is apparent that in the driven wheel, as with the driver, the tooth against the outgoing link is the one in action.

Mr. W. D. Ewart, in his invention of the differential-pitch sprocket wheel, has combined the principles that the driver wheel pitch shall be large and the driven wheel pitch small, in a single wheel.

A careful study of the action of a chain gearing with a wheel shows that unless the wheel face is kept well lubricated, which in practice is rarely the case, a more perfect action is secured by the type known as the roller chain than by the ordinary solid joint chains, like the block chains or Ewart chains, because the release of the outgoing link and the slipping back of the remaining links is accomplished with less jar and with less wear on the external part of the chain joint by rolling than by sliding.

The ratio of the roller to its pin should be as large as the strength of the chain will permit, but without encroaching too much upon the tooth space of the wheel; for the above analysis also points out the fact that the greater the number of teeth, the larger must be the space between them in order to take care of the elongation of the chain when worn. This means that the larger the number of teeth, the thinner the tooth. This is sound from a practical standpoint, because, chain speeds being the same, the greater the number of teeth, the less frequently does each tooth come into action. There is a limit to the number of teeth which a wheel should be given, and this limit—not the possible limit, but the practical limit—can be set down at 100 for cut wheels gearing with accurately pitched machine-made chains, and at less than half this number for cast wheels and cast chains.

It is evident from the foregoing cuts that in the operation of any of the ordinary chains, no matter how accurately made, and no matter how correctly cut the wheel, the transfer of strain from one link to the following involves a blow which becomes more frequent, and therefore more severe, as the speed increases. Take the case

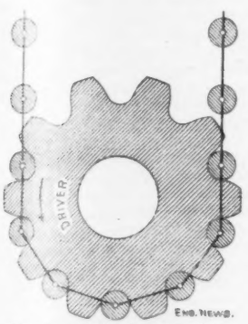


Fig. 1. Faulty Construction of Wheel When Gearing With a New Chain.

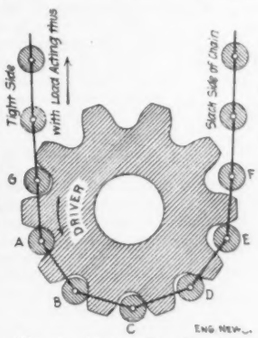


Fig. 2. Faulty Construction of Wheel When Gearing With a Chain Slightly Worn.

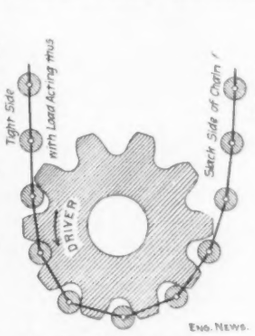


Fig. 3. Faulty Construction of Wheel When Gearing With a Worn Chain.

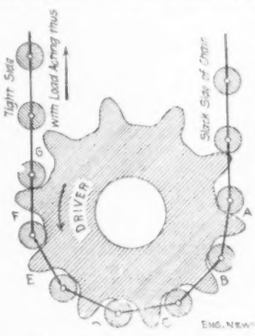


Fig. 4. Correct Construction of a Driver Wheel When Gearing With a New Chain.

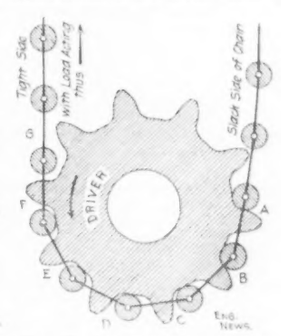


Fig. 5. Correct Construction of a Driver Wheel When Gearing With a Chain Slightly Worn.

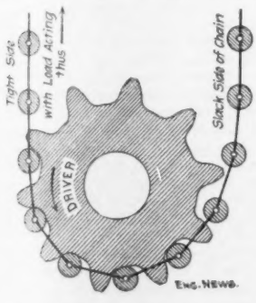


Fig. 6. Correct Construction of a Driver Wheel When Gearing With a Much Worn Chain.

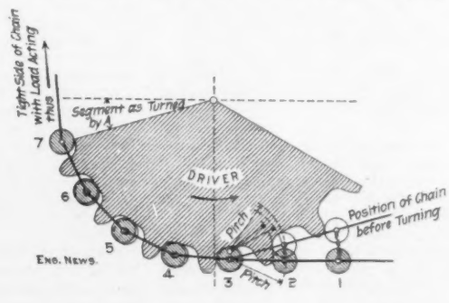


Fig. 7. First Stage of Outgoing Chain.

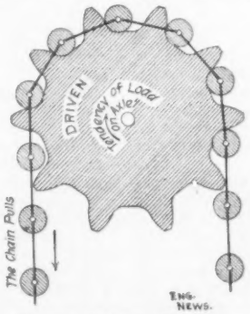


Fig. 8. Correct Construction of a Driven Wheel When Gearing With a New Chain.

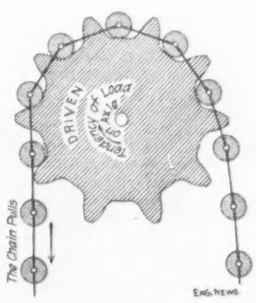


Fig. 9. Correct Construction of a Driven Wheel When Gearing With a Worn Chain.

of a chain of 3 ins. pitch traveling 900 ft. per minute: Each foot of travel means the engagement of four links, and this speed, therefore, represents 3,600 blows to the chain per minute.

The severity of the blows is still further increased by the fact that the chain at high speeds vibrates in both a vertical and a horizontal plane and strikes heavily against the face of the wheel in consequence. The heavier the chain, the greater the force of the blow and the quicker the destruction of the chain.

In designing chains for high speeds, therefore, material of the very highest degree of strength and tenacity must be selected so as to keep down the weight. We have experimented for a long time on the determination of the proper strain which a chain can be called upon to transmit at various speeds, and while our experiments are not complete enough to tabulate, they show that, for malleable iron chains, for instance, the permissible strain must be quickly reduced as the speed is increased.

Suppose, for instance, that in the accompanying diagram (Fig. 10) the horizontal divisions represent speeds and the vertical divisions effective horse-powers. Then, if we follow the generally accepted method of horse-power determination for chains, we will assume the permissible working strain to remain the same at all speeds and obtain the results shown by the straight dotted line. If, however, we take into account the rapidly increasing destructive effect of blows at high speeds, we will find

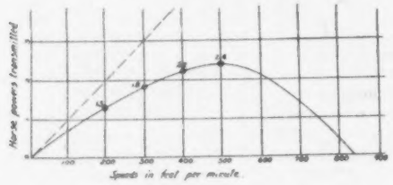


Fig. 10. Curve Showing Variation in Power Transmitted With Variation in Speed.

that the effective power transmitted is represented by a line which assumes the shape of a curve, flattening as the speed increases and finally dropping back.

The actual strain in chain, however, increases with the speed, and the chain can be run so fast that it will destroy itself without performing useful work. Our experiments fully bear out this theory, and indicate that a malleable chain at 200 ft. can be safely run at twice the working strain of one at 50 ft., and that at 500 ft. the chain will transmit its maximum power. These statements are all made, of course, on the assumption that the total strain existing in the chain—that is, the sum of the strain due to the driving force and that due to impact—shall be the same at all speeds.

Now, as stated above, the limitations to chain speeds are due, first, to the weight of chain; and, second, and more particularly, to the method of engagement. High-speed chains must therefore be light; they must be accurately made as to pitch, and they must be made durable so they will retain their accurate pitch. The wheel must likewise be accurately cut and the teeth formed in such a way that the transfer of strain from one tooth to the following one is made with the least possible jar.

But with all these requirements fulfilled, chain speeds of 1,000 ft. per minute and upward are objectionable for most transmissions because of the noise. This noise is due wholly to the manner of engagement between the chain and chain wheels, and increases very rapidly as the chain stretches from wear.

To Mr. Hans Renold, of Manchester, England, belongs the honor of having developed a driving chain which overcomes the defects inherent in the ordinary type of chains, and makes it possible to attain speeds of 1,200, and even 1,500, ft. per minute, with as little noise as accompanies the action of a leather belt. This he accomplished by so designing the chain and wheel that the stretch is automatically taken up, or rather compensated, and the correct principle of chain gearing is preserved to the last. The compensation for stretch or wear is accomplished on the wheel by the chain assuming automatically a larger pitch diameter, this result being achieved by the peculiar form of link and tooth. The incoming link seats itself firmly against the face of the tooth, and retains this position until its release at the other end of the driving arc. There is no transfer of load from tooth to tooth by slipping back, but the load is evenly distributed over all the teeth in gear, and the action is altogether silent and without the slightest trace of jar or jerk.

The "silent chain gear," as Mr. Renold has styled it, is very durable, and has lent itself to purposes where chains have heretofore been inadmissible.

It seems strange to see a sprocket wheel on the shaft of a motor running 800 revs. per min., and to find a chain transmitting power from this motor to a countershaft with a speed reduction of 5 to 1. And yet this chain does its work as noiselessly as a belt, and very much better than a cut gear and a rawhide pinion. The illustrations of this chain are so clear as to explain themselves, and demand no further description.

As all the teeth in gear are simultaneously in action, and as this continues to be the case even when the chain becomes worn, it is evident that several chains can be

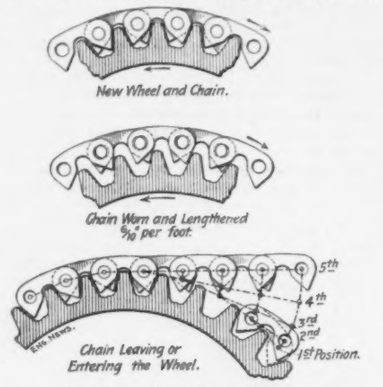


Fig. 11. Silent Chain Gear.
Hans Renold, Manchester, England, Inventor.

run simultaneously on the same wheels, and that each will do its proper proportion of the work. This makes it possible to transmit large powers by using a number of chains side by side, and several very successful installations transmitting 150 HP. and over have been made by Mr. Renold in this way.

Accurate workmanship in both chain and wheels is absolutely necessary, and machine-cut wheels must therefore be used.

Several years ago Mr. James M. Dodge designed a sprocket wheel for use with the Ewart or other form of

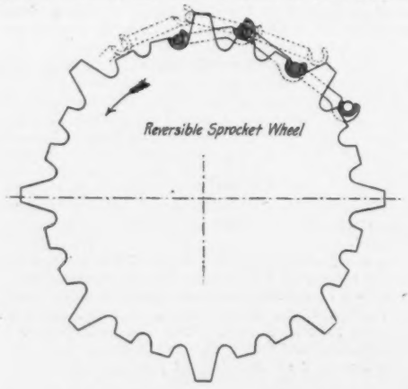


Fig. 12. Reversible Sprocket Wheel.
Jas. M. Dodge, Philadelphia, Pa., Inventor.

malleable iron chain, in which the wear of the chain is compensated for by its assuming a gradually increasing pitch diameter, as in the case of the Renold silent chain gear. The design, however, is quite different, as will be seen from the illustration (Fig. 12). In a long series of dynamometer tests, wheels of this design, made of chilled cast-iron, have shown themselves indestructible when used as drivers, and have shown that by their use the life of the chain can be practically doubled.

In conclusion, permit me to say that chain gearing, when properly designed and taken care of, is as little subject to derangements as any other power-transmitting medium. Recent developments will no doubt greatly extend the range of application of this form of transmission, and will call for a better understanding of the correct principles that underlie chain gearing by the mechanical world.

BOOK REVIEWS.

NEW TABLES FOR THE COMPLETE SOLUTION OF GANGUILLET AND KUTTER'S FORMULA FOR THE FLOW OF LIQUID IN OPEN CHANNELS, PIPES, SEWERS AND CONDUITS.—In two parts. Part I. Arranged for 1,080 inclinations from 1 over 1, to 1 over 21,120 for 15 different values of (n). Part II. For use with all other values of (n). By Colonel E. C. S. Moore, R. R., M. S. I., formerly Instructor in Estimating and Construction at the School of Military Engineering, Chatham. Author of "Sanitary Engineering," etc. London: B. T. Batsford. New York: D. Van Nostrand Co. Cloth; 6 × 9 ins.; pp. 231; one folding plate. $5.

The contents of this book are quite well indicated by the foregoing quotation of the title page. There are only a few pages of text. The first 165 pages give the values of N, Log. n., and D, for special inclinations and values of n. Then comes a general hydraulic table for [illegible] channels, followed by values for pipes with di[illegible]ers of from 3 to 36 ins. A number of special tables co[illegible]e the volume, except for a large folding sheet, on w[illegible] is a diagram for the graphic solution of the value [illegible]

HAND-BOOK OF FIRE PROTECTION FOR IM[illegible]VED RISKS.—By Everett U. Crosby, Secretary [illegible]ional Fire Protection Association, and Henry A. Fis[illegible] Manager Underwriters' Bureau of New England [illegible]ston. The Standard Publishing Co. Leather; 5 × 7 [illegible] pp. 312; illustrations and tables. $3.

The very features that make this book useful [illegible] underwriter inspectors render it valuable for architects [illegible]d engineers who are called upon to design safe build[illegible]s and make plans for their protection against fire. Ow[illegible]s and superintendents of buildings, also, will find it us[illegible] It brings together a large amount of information o[illegible]low-burning construction, storehouses for special cla[illegible]s of goods, automatic sprinklers, alarm valves, pumps, p[illegible]ssure tanks, fire hose, water supply and fire protection g[illegible]ally, electric wiring, acetylene risks and the like. A larg[illegible] part of this matter is in the nature of regulations ado[illegible]d by the National Fire Protection Association and simila[illegible] organizations. The book was first published in 1896, but has been brought up to date in the present edition.

BROWN'S DIRECTORY OF GAS COMPANIES.—Compiled and Corrected by E. C. Brown. New York: The Progresive Age. Cloth; 7 × 10 ins.; pp. 202. $5.

This volume gives the leading facts relating to the gas works of the United States and Canada and some information as to the electrical departments of gas companies, when such departments exist. There is also a section devoted to acetylene plants, comprising twelve in all, and a more list, by states, of 21 gasoline plants. We had supposed, from statements published in the papers devoted to acetylene, that there were more than a dozen towns so supplied. A handy feature of this book is a list of the officers and members of the various gas associations in the United States. A few pages are devoted to various standards adopted by gas associations, including dimensions of cast-iron gas pipe and specials. Nine large pages are given up to the "Calorific Power of Fuels and Gases." This section is reprinted from Gill's "Gas and Fuel Analysis." Finally, we may mention a handy priced list of books for gas men, and a discussion by W. W. Christie of "A Boiler Horse Power."

TOWERS AND TANKS FOR WATER-WORKS.—The Theory and Practice of Their Design and Construction. By J. N. Hazlehurst, M. Am. Soc. C. E. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 6 × 9 ins.; pp. 210; tables and illustrations. $2.50.

This is the first book to appear in a field where the need of a general treatise has long been felt. The only special work heretofore available has been Professor Pence's "Stand-Pipe Accidents and Failures." The importance of the subject may be better realized when it is stated that there were in the United States, at the close of 1896, no less than 992 water-works "equipped with some form of elevated metallic storage tanks or reservoirs." The author gives an interesting table, compiled from "The Manual of American Water-Works" for 1897, showing the number of stand-pipes in each State of the Union, their diameter, height, whether of iron or steel, and the lowest and highest pressure on the distribution system. So far as the material is given, 228 of the stand-pipes are of steel and 196 are of iron. Of metal tanks on towers the author states that statistics of his own compilation show 161, mostly erected since 1890.

After the introductory chapter, from which the foregoing citations have been made, the author takes up the chemical and physical properties of steel and wrought iron, compares the two metals, and discusses the forces acting upon stand-pipes and tanks and the principles involved in resisting these forces. Riveting is given a separate chapter. There are two chapters on designing, and one each on foundations, painting and shop practice and erection.

As might perhaps be expected from the nature of the subject and the modest size of the book a goodly part of the contents is composed of quotations from standard specifications and various other writers. These appear to be well chosen, and the author's discussion of the respective topics in hand is such that the book is in no sense a mere compilation. Nearly all the quoted matter was originally widely scattered, and some of it would never be found by the ordinary engineer, since it relates to structural material in general.

Illustrations might well have been used more freely. The rapid displacement of wooden trestles, or towers, for supporting elevated tanks, may excuse the mere mention which they receive, but in a book with such a title as this, one has a right to expect at least a chapter on wooden tanks. We should say that there are many more wooden than steel tanks in use to-day. True, the wooden tanks are often quite small, but the fire protection of many a small town in the middle and central west depends upon just such structures, while the number in use by manufacturers, railways, farmers and others throughout the country is legion.

We wish to call attention to the fact that the chapter on painting makes the book of possible value to every water-works in the country which has to maintain a metal

tank or stand-pipe. The index has the faults common to most books. Thus, on the first page alone we find such entries as "ancient cast-iron tank," "average stand-pipe," "arrangement of members," "built columns," and "bearing ...."

A 4½-DAY ATLANTIC VOYAGE is proposed by the projector of a scheme for a new harbor at Berehaven, on the west coast of Ireland, a bill for which has been passed by the British Parliament. The plan is to establish piers and other facilities for a line of fast ocean steamers, connecting with express trains across Ireland, fast steamers across the channel and express trains on the English railways. The project is about on a par with that for a steamship service to and from Montauk Point, on Long Island, with express trains between that place and New York, and we have already shown that there is little, if any, demand for a service of this kind, with its additional railway journey and trans-shipment. The Irish scheme is even worse, as it would involve a few hours' railway ride, then a few hours' steamboat ride and then still another railway ride to the passenger's destination.

THE UNITED STATES PATENTS issued in 1900 numbered 26,499, a greater number than the record of any previous year. The previous record number was 26,292, which was the number of patents issued in 1890. The Commissioner of Patents in his annual report urges that attention be given by Congress to much needed reforms in the patent system and in the administration of the office.

THE APPLICATION OF CHEMISTRY to foundry practice was commented on as follows by Mr. A. L. Colby, of the Bethlehem Steel Co., at the recent annual meeting of the American Foundrymen's Association:

> The application of chemistry to steel metallurgy has resulted in such rapid advances that I am anxious to see chemistry become an equally important factor in foundry practice. I think the present prejudice against the purchase of foundry irons entirely on analysis, is due largely to the inaccurate chemical analyses quoted in the trade. These inaccuracies are due either to careless analytical work, or more often to poor sampling.
>
> A founder endeavors honestly to apply chemistry to the selection of his pig irons, and to the mixing of his irons in the cupola, but becomes discouraged because he can see no practical benefits, and so returns to selecting his iron by the appearance of its fracture. I venture to say that in the majority of cases his failure is not so much due to his lack of perseverance as to the fact that the samples analyzed did not properly represent the casts of iron he was using, and perhaps also to the fact that he has called in that most expensive of luxuries to an iron works, a cheap chemist.
>
> A steel works chemist, and an analytical machine who turns out so many analyses a day, are two different personalities.
>
> Let the foundryman pay enough to secure a good chemist, then give him entire charge of the sampling and give him access to the foundry records, and I venture to say that at our next convention much testimony will be given as to the practical value resulting from the application of chemistry to the selection and mixing of foundry pig irons.

WILLIAM LUDLOW.

Brigadier-General William Ludlow, United States Army, died of consumption at Convent Station, N. J., on Aug. 30, aged 58 years. Gen. Ludlow had been ill only a few months. His disease made its appearance soon after his assignment to duty in the Philippines last winter, and he returned to the United States in the hope of restoring his health, arriving in San Francisco last May. Since that time he has been with his family at Convent Station, N. J. His funeral was held, with the military honors due to his rank, in Trinity Church, New York city, on Sept. 3. That stately old edifice has seen the funeral rites of many a distinguished soldier and statesman; but surely none of them better deserved the tribute paid for faithful defence of the country's honor than the brave officer whose life we here briefly record.

Wm. Ludlow was born at Islip, L. I., Nov. 27, 1843. His father was brevetted Major-General for gallant service in the Civil War, and the son entered West Point just at the breaking out of that great conflict. He graduated in 1864, his class numbering among its members such now well-known men as Lydecker, Stickney, Mackenzie, Ernst, Heap and Damrell. He was commissioned First Lieutenant in the Corps of Engineers on his graduation, and was at once ordered to the front, where in the few months that remained of the war he was successively brevetted Captain, Major and Lieutenant-Colonel, for gallant conduct in the defense of Allatoona Pass, in the campaign through Georgia and in the campaign in the Carolinas. He was successively Chief Engineer of the 20th Army Corps, Chief Engineer of the Army of Georgia, and Assistant Engineer of Sherman's army during the March to the Sea and the invasion of the Carolinas. He participated in the battle of Peach Tree Creek, only five weeks after his graduation, and besides the battle of Allatoona Heights he was in the battle of Averysborough, the battle of Bentonville and the actions at Goldsbrough and Raleigh.

At the close of the war he was assigned to duty at Jefferson Barracks, St. Louis, and while stationed there he was married to Miss Genevieve Sprigg, of St. Louis, a cousin of Mrs. Winfield S. Hancock.

He received a commission as Captain in the Corps of Engineers on March 7, 1867, within less than two years from his graduation, and served five years under Major Gillmore. The four years from 1872 to 1876 were spent as Chief Engineer of the Department of Dakota. He was then successively under Col. Kurtz and Col. Macomb, serving four years under the latter on various river and harbor works in New Jersey, Pennsylvania and Delaware. From 1882 to 1883 he was engineer-secretary of the Light-House Board, having been promoted to the rank of Major.

In 1883, by some convulsion in politics, whose origin is unknown to the present writer, Major Ludlow was appointed Chief Engineer of the Philadelphia Water Department and was given a leave of absence from the Army for three years to accept the position. The Department had long been honeycombed with corruption, and Ludlow was selected as the man to inaugurate a reform. Those who selected him made no mistake. The story is an old one, yet it may be new to some of

William Ludlow, Brigadier-General, U. S. A.

our readers, of the reception that Major Ludlow gave to a contractor who had some personal axe to be ground and called in to see the new Chief Engineer about it.

He was ushered into the Major's office and seated by his desk, and the two were soon engaged in conversation. While the contractor talked he nonchalantly drew a $50 bill from his pocket and laid it on the desk before Ludlow. The latter paid no attention to it for a little, while the conversation continued, and then he likewise carelessly picked it up and rolled it between his fingers, while the contractor inwardly exulted at the thought that the new "reform man" was like all the rest. He felt the matter clinched, when the Major in the most affable manner possible offered him a cigar. What was his astonishment the next moment to see Major Ludlow calmly hold the end of that $50 bill in the gas jet and light his cigar with it, after which he politely offered the still burning end to the contractor, with the stereotyped "won't you have a light?" The contractor had nerve enough left to light his cigar; but it is doubtful whether he extracted much comfort from it.

We give space to this little incident not because of its importance, but because it typified the character of the man, who, whether the temptation were great or small—whether the tempter were a petty contractor or a wealthy syndicate, was not to be swerved from the path of duty.

Following his Philadelphia experience, Major Ludlow served about two years as Engineer-Commissioner of the District of Columbia, a position for which his work in Philadelphia had especially fitted him. He was then transferred to the Light-House Board, and served in the Fourth, Ninth and Eleventh Districts and also on river and harbor works in western Michigan.

In 1893 he was appointed Military Attache of the American Embassy at London. In 1895 he was appointed to what we believe was the most important and onerous engineering work of his life, being made one of a commission of three engineers to report upon the feasibility of the plans and surveys for a ship canal, made by the Interoceanic Canal Co., of Nicaragua. As many of our readers will remember, this company had been for years before Congress with a bill asking the Government to guarantee the bonds of the canal company, under a plan by which the United States would assume the risk and the canal company would reap the profits. The canal company declared that its plans and estimates were sufficient. Had the board of which Col. Ludlow was a member approved the canal company's plans, there is little doubt that the company's bill, which had so long been hanging fire, would have passed at the next session of Congress. The commission of three engineers were given only $20,000 with which to make their investigation, including their own compensation and expenses. Their entire work was done and their report prepared between April and October, 1895. They found the company's plans inadequate and their estimates unreliable and insufficient, while grave doubts were thrown on the feasibility of the route which the company had adopted. The report killed the Maritime Canal Co.'s projected raid on the Treasury. The plain facts reported by three unprejudiced engineers could not be got around and the strenous attempts made to pass the canal company's bill resulted in failure. Since that time two other Government commissions have investigated the canal routes, one with $150,000 and the other with $1,000,000 at its command. The results of these detailed surveys have confirmed in a most remarkable manner the soundness of the conclusions reached by Col. Ludlow and his colleagues.

When the Spanish war began, Col. Ludlow was in charge of the U. S. Engineer office in New York city. He at once went to the front, and was commissioned a Brigadier-General of Volunteers and assigned to the command of a brigade in General Shafter's army. He was universally conceded to be one of the most efficient and able officers who served in the Santaigo campaign, and his troops rendered important service in the final capture of the city.

At the close of the war he was made military commander of the Department of Havana. Words are too weak to express the value of his services to his country and to humanity in this position. The revolution which he and his faithful assistants created in the condition of that city is a feat of which every American may be proud. In such work deeds may be done as truly heroic as any recorded on the battle field. General Ludlow was as efficient in the one place as in the other. He labored as diligently to protect the treasury of Havana from the attacks of scheming politicians as he did its people from the attacks of fever.

We have little doubt that his onerous work in Havana did more than anything else to undermine his constitution and cause him to yield to the disease that finally proved fatal.

After his return from Cuba, Gen. Ludlow was assigned to duty in forming plans for a Naval War College and went abroad to study foreign institutions of that sort. He was then ordered to the Philippines to succeed Gen. Hughes in command of the southern islands, but he was stricken by disease before he could take charge.

Gen. Ludlow was elected a member of the American Society of Civil Engineers in 1882. His wife survives him, and one daughter, who is the wife of Mr. Clement A. Griscom, Jr., of New York city.

ENGINEERING NEWS
AND
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We urge every one of our readers who is a member of the American Society of Civil Engineers to send in his ballot in favor of the appointment of a committee to revise the Society's standard rail sections, provided he has not already done so. It is doubtful whether any act of this Society has been of wider public benefit than its preparation of a set of standard rail sections in 1893. It is stated that in 1899 three-quarters of all the rails rolled in the United States were of the American Society standard section. There is strong evidence, however, that certain changes in these standards, for the heavier sections especially, have now become advisable, and a movement to have the Society undertake this work has been agitated for some time. At the recent Niagara Falls meeting, the Board of Directors recommended that a committee be appointed to undertake this work of revision (provided its investigations showed such revision to be advisable). Before such a committee can be appointed, however, a letter ballot has to be taken, and at least one-third of the corporate members of the Society must vote in its favor. On Aug. 14, the vote on this proposition still lacked 148 of the necessary number, and there is danger that the appointment of the proposed committee may fail merely from inertia.

The fact is that the framers of the Am. Soc. C. E. constitution provided so much red tape and so many safeguards to prevent the Society from taking action by special committees on engineering subjects, that they overstepped the mark. In the present case, for example, there is, so far as we are aware, no opposition whatever to the appointment of a committee to revise the Society's standard rail sections. When a letter ballot is sent out, however, one can be certain that from one-fourth to one-half the members will not take the trouble to fill it out and remail it, no matter what its subject. Some are retired, or engrossed in lines of business remote from professional work, and pay no attention to the Society or to engineering matters of any sort; others are traveling, perhaps, in remote corners of the globe; others are ill; other still from mere inertia will never take the trouble to return their ballot, or will delay it until too late. Finally, out of the remaining members of the society a very considerable portion are engaged in lines of engineering work where the form of rail sections is of no interest to them. They neither know nor care anything about the subject, and when a letter ballot on rail sections is sent them they feel that it is a matter on which they have no opinion, and so refrain from voting. It is to this last-named class of members that we would especially appeal, and urge them to vote for the appointment of the committee for the sake of the Society, and the opportunity it has here to continue the good and useful work it has already begun.

Nearly all those who are really interested in having the proposed committee appointed have probably already cast their ballots. Unless members whose interests lie in other fields will take the trouble to send in ballots on the question therefore, the whole project may fail. It is to be hoped that the interest of this class of members may be aroused; but the present situation, whatever the outcome, should lead to a revision of Article VI., Sec. 11 of the Society's Constitution in such a manner as to cut away some of the red tape by which its work is now hampered..

It begins to look as if the New York Central & Hudson River R. R. Co. would have to actually do something to improve the conditions in the Park Ave. tunnel, by which its trains enter New York city. Previous agitations respecting the condition of this tunnel have come and gone, and the smoke and the steam have hung round it still. At present, however, the District Attorney's office, the Board of Health and several of the New York daily papers are all pitching into the tunnel question, very likely with more zeal than wisdom, but in a manner that is calculated to convince the New York Central officials that the time has at last arrived for action.

As narrated in another column, the Board of Health has officially ordered the railway company to provide sanitary accommodations for its tunnel employees—which is easy—and to tear out the brick division walls between the single-track side tunnels and the double-track central tunnel—which is very far from easy.

Of course it can be done; but it will be a long and difficult job on account of the necessity of carrying on the work without interrupting traffic, and it will cost, we should judge, nearly as much as it would cost to install an efficient ventilating system, which would solve the whole tunnel difficulty at once.

Moreover, how much will be gained by tearing out these brick walls and substituting steel columns and girders in their place? The air in the side tunnels will be improved, doubtless; but the air in the central tunnel will be worse, and the nuisance along Park Ave. from noise, steam and smoke will be intensified. There is one point, too, which the Board of Health in its ignorance of railway matters appears to have overlooked, and that is the risk involved in the introduction of columns instead of walls to support the tunnel roof. Suppose a derailment occurs in the tunnel—something that is possible at any time. A derailed car or engine might easily swerve to one side, knock down a row of columns and bring the roof of the tunnel and the street above crashing down upon the train. Engineers familiar with railway service are very careful how they place the columns which support important structures where they can be reached by derailed cars. We can call to mind numerous accidents where loss of life has occurred in railway wrecks, not from the derailment itself, but from the collapse of buildings, platform roofs, water tanks and other structures whose supports were knocked away by derailed cars or locomotives. It seems to us that the city authorities should give pretty serious consideration to this matter before they compel such a change in the Park Ave. tunnel as they have ordered, especially as the benefits to be derived from such a change are, as stated above, by no means certain.

It is stated that the engineers of the company are now working on a plan by which the suburban trains through the tunnel will be handled by electricity and will use the side tunnels, leaving the central tunnel for through trains, which will continue to be hauled by steam locomotives. To get over the difficulty of handling the electric cars in the yards, a loop will be made in tunnel underneath the yard and underneath the present tracks in the station, the whole being similar to the arrangement adopted at the Southern Terminal station in Boston.

Very likely when the company is ready to move its suburban traffic by electricity, some such scheme will be adopted; but no steam railway company which has investigated this question has thus far dispensed with its locomotives. The Illinois Central, for example, went very fully some years ago into the project for handling its Chicago suburban traffic by electricity, but after an exhaustive investigation the locomotives were suffered to remain in service. The New York, New Haven & Hartford R. R., too, has accumulated a large amount of experience with electric traction, and its adoption of electricity on its Berlin line and its Nantasket Beach line some years ago was heralded abroad as sounding the doom of the locomotive. But the New Haven road has extended its experiment no further. Its vast suburban traffic about Boston is still moved with steam locomotives, and the subway loop at the South Terminal station, referred to above, remains unused.

We point out these facts merely to show that the maledictions which are being heaped on the New York Central company because it has not long ago adopted electric motive power for its trains are quite unwarranted.

The problem of substituting electric for steam motive power is far larger and more complicated than most people imagine; and if the New York Central does make such a change for its entire suburban traffic, it will be the pioneer in the field.

There is room for doubt, also, whether the adoption of electric motive power for the suburban traffic would satisfy all needs. The smoke and steam from all the through trains over the New York Central and New York, New Haven & Hartford roads would still pollute the main tunnel and trouble the dwellers alongside it. The growing suburban traffic could not be confined to a single outgoing and a single incoming track, and it is doubtful whether a single loop track beneath the station would afford sufficient terminal facilities. Even were the electric motive power adopted for all trains, the noise will still remain to cause complaint from the Park Ave. residents, and this noise will be notably increased by the changes which the Board of Health has now ordered, increasing the openings in the tunnel roof.

We still believe, therefore, that the proper method to remove the Park Ave. tunnel nuisance is as outlined in our issue of July 11, to close the roof openings and install forced ventilation appliances sufficient to clear the tunnel of smoke and steam and discharge it above the roof level. The question of electric motive power can then be considered independently.

The Tripler Liquid Air Co., against which we warned our readers over a year ago, is again attracting public attention in New York, and its remarkable financial transactions may yet be investigated in the courts. According to published statements, the company was capitalized at $10,000,000 in $10 shares, and of this amount shares to the par value of $5,000,000 are said to have been turned over to the directors in consideration for the use of their names, while $2,500,000 of the stock went to Mr. Tripler for his patents. The public was then invited to subscribe for 100,000 shares out of those still remaining, and Gerald M. Fennell & Co., of Boston, were appointed selling agents. Huge advertisements were inserted in the newspapers and glowing prospectuses and pamphlets were sent broadcast over the country. In this way about 50,000 shares of stock are said

to have been sold, netting about $250,000. Of this sum about one-third went in commissions, another third went for advertising, and the rest appears to have been frittered away on office expenses, Tripler's exhibit at Paris, a liquid air motor carriage, and some work on a new factory. It is said that over 4,000 people have purchased the company's stock.

The folly of allowing rival gas companies to lay duplicate sets of mains under city streets in the vain hope of creating competition is pretty well understood now; yet a parallel piece of folly is being enacted in the construction of rival telephone systems with duplicate sets of underground cables. A recent dispatch from Memphis, Tenn., tells of the litigation between two rival companies in that city over a point in an alley where the new company has barely room to squeeze its conduits past a manhole of the old company. Meanwhile the city authorities look passively on, as if it were of no moment to the city to have the whole space underneath the street surface available for underground piping preempted by private companies.

Of course, in the end the two companies will consolidate and the interest charges on the money wasted in the duplicate underground system will be made the excuse for high telephone rates.

THE OCCURRENCE AND TREATMENT OF CAISSON DISEASE IN ENGINEERING WORKS.

The morbid phenomena exhibited by men who perform physical labor under high atmospheric pressures have been observed and commented on by engineers on numerous occasions. In a few instances, these phenomena have been given special study by physicians. So far, however, although many theories have been advanced in explanation, no very clear notion is had by either engineers or physicians of the actual cause of the malady commonly known as caisson disease. Experience has given only a few general facts, by knowledge of which we are able to palliate the worst results of the disease and which define in a general way the limit of pressure beyond which it is not wise or economical to subject workmen. It may be said frankly that this appears to be a somewhat meager record of knowledge for over 60 years' use of compressed air in hundreds of engineering works, each of which has furnished its quota of illness and often of death due to high atmospheric pressure, and that it does not seem to be sufficiently explained by the legitimate difficulties of the problem to be solved. It is not expected that we can remedy this fault here, but it seems worth a little space to point out the position, so far as the layman in medical lore is able to define it, which has been reached in our knowledge of caisson disease, and to ascertain, if we may, to what extent this knowledge is capable of practical application by engineers.

This inquiry is perhaps best approached by propounding a series of questions and in observing what answers to them past experience in compressed air work affords. The first question to which engineers are interested in securing an answer is: What is the cause of the peculiar effects experienced by men working under high atmospheric pressure, and which are commonly known as caisson disease? The second question is: Is this cause a necessary and inseperable condition of work under air pressure? The third question is: What remedial treatment has been found to be most efficient in mitigating the severity of attack by caisson disease? Bearing upon these three questions is a fourth, which can be stated as follows: Under what maximum pressures has compressed air work been successfully prosecuted and what were the chief factors which apparently contributed to this success? The task is to discover what past experience and study furnish us in the way of answers to these questions.

The symptoms of caisson disease have been quite definitely established. First among them are neuralgic pains of an intermittent or paroxysmal character, and of varying severity. In the worst instances these pains, or cramps, as they are commonly called, although they are rarely accompanied by muscular spasms, are so intense as completely to unnerve strong men. This symptom is very seldom absent, and from it comes the popular name of "bends" given to the disease. Another characteristic symptom which is always exhibited is a profuse cold perspiration. Another symptom which is of frequent occurrence, but which is not always exhibited, is pain at the pit of the stomach, usually, but not always, attended by vomiting. In about 50 per cent. of the cases observed, paralysis has been a characteristic symptom. The degree of paralysis varies from slightly impaired sensation or numbness in the extremities to complete loss of sensation and motion in the affected parts, which are most frequently the legs and lower part of the body. Finally the sufferer usually exhibits a number of transient symptoms, which have their origin in the brain; these are headache, dizziness, double vision, incoherence of speech and sometimes unconsciousness. The duration of these symptoms varies from a few hours to several weeks in case of paralysis. In fatal cases congestion of the brain or spinal cord always exists. A very noticeable fact is that the attack of the disease never takes place while the subject is under air pressure, but always occurs while he is emerging from the compressed air chamber or after he has emerged. It is also well established that the danger of attack and its severity are directly proportioned to the intensity of the pressure and the length of the period during which pressure is endured.

So much for the symptoms and pathology of caisson disease; our first question is: What are the causes which bring about these morbid phenomena? This is obviously a question for the medical men to answer, and not one for the engineer, and a little study shows that medical men are not very well agreed upon an answer. A few references will illustrate the truth of this statement, and will also set forth the principal theories which have been advanced in explanation of caisson disease.

In his study of the malady at the Eads Bridge in 1871, Dr. Jaminet, the physician in charge of the compressed air laborers, arrived at the conclusion that the ill-effects of compressed air are simply the result of exhaustion from too rapid tissue-change caused by the absorption of an excess of oxygen. His treatment of the disease accordingly consisted merely of rest in a recumbent position, with the feet elevated, and in the administration of stimulants and nourishment. The investigations of Dr. Andrew H. Smith, the surgeon in charge of the work of sinking the pneumatic caisson foundation for the New York tower of the New York & Brooklyn Bridge, led him to a conclusion quite different from that of Dr. Jaminet. In passing, the fact deserves to be noted that Dr. Smith's report upon his investigations is one of the most instructive and exhaustive documents on the subject which has ever been published. The causes to which this physician ascribes caisson disease are briefly as follows: The superficial pressure of the air upon the body acts to force the blood from the surface to the center or to cause internal congestion. To illustrate, the condition of the different parts of the body in regard to the supply of blood while under pressure may be described as follows: The skin and the superficial structures are anaemic. The central portion of the limbs and the interior organs of the body are congested. The solid viscera of the abdomen are especially engorged on account of both situation and structure. The brain and spinal cord, and the interior of the shafts of the long bones are congested at the expense of all the other parts. It is considered that these changes are not perfected until a considerable time has been passed in the compressed air, and, similarly, that the recovery of normal conditions does not occur until some time after emerging from the compressed air. "Hence," to quote Dr. Smith's words, "the circulation will be languid and the congested parts will not readily empty themselves of the excess blood which they contain. The capillaries being clogged with effete blood, the nutrition of the part will suffer, and disturbance of function will result."

The third theory to account for caission disease, which we will mention here, is that of Dr. Wainwright, the physician of the Waterloo & City Ry. work in London, and of Dr. Snell, who had charge of the men employed in the compressed air work on the Blackwall Tunnel. This theory, as stated by Sir Alexander Binnie and by Mr. A. H. Haigh in another column of this issue, is, in substance, that the blood and viscera absorb oxygen, nitrogen and carbonic acid, and the latter gas in particular, and that the physiological effect of the carbonic acid gas and the mechanical action of all three gases in escaping through the tissues upon the release of pressure, are the causes of the morbid symptoms which characterize the malady under consideration.

We shall not attempt to decide between, or to reconcile, these complicating theories here, but it is plain that they do not help the engineer much to answer the question in which he is vitally concerned, namely: Is the cause of caisson disease a necessary condition of work under air pressure? If the theory of either Dr. Jaminet or that of Dr. Smith is the true one, it would appear that the malady must necessarily accompany all work under high atmospheric pressures. Or the other hand, should the theory of Dr. Wainwright, which is concurred in by Dr. Snell, be the true theory, then we may reasonably assume that the cause is not altogether a necessary and inseperable condition of work under high air pressures, but one which may be partially overcome or counteracted by better ventilation. It deserves to be noticed in this connection, that the records of the London tunnel work upon which the English physicians base their conclusions, afford considerable evidence in support of the efficacy of thorough ventilation in reducing the danger of caisson disease. In our opinion, the discussion which we publish in another column is chiefly valuable because of the evidence which it presents upon this point. It would be exceedingly interesting to have the testimony of other experienced engineers upon the same point. It can hardly fail to be observed by anyone who examines the records of compressed air work that in several notable instances where very high pressures have been employed, there has been remarkable freedom from caisson disease as compared with other works in which lower pressures were utilized. Compare, for example, the pneumatic foundation work on the new East River bridge, in which no serious case of illness resulted, with that on the Brooklyn Bridge, where over a dozen workmen suffered severe paralysis and three others died. At the new East River Bridge the pressure was 46½ lbs., and at the Brooklyn Bridge it was 36 lbs. Is it possible that the use of electric lights, the cooling and washing of the air by sprays, and the other improved methods of compressed air supply at the more recent work kept the air so much more pure than at the Brooklyn Bridge work, where gas lights were used and the air supply was much less carefully protected, as to account for the comparative freedom from disease?

Some very suggestive data which seem to have a direct bearing upon this question were obtained in the experiments made by Mr. Hersant, the engineer in charge of the new harbor works at Bordeaux, France, in 1895. The results of these experiments were given in some detail in Engineering News of Aug. 1, 1895, and only the general results will, therefore, be considered here. In these experiments a man actually endured an air pressure of 76.8 lbs. per sq. in. for one hour, 45 minutes being consumed in attaining this pressure and about three hours in reducing it to normal atmospheric pressure. It was concluded from the experiment that, if precaution were taken to ensure good ventilation and warm surroundings, a healthy man could endure air pressures of at least 76.8 lbs. with safety. In these experiments no physical exertion was required of the men, and in this respect they were hardly comparable with the conditions in regular compressed air work in engineering construction. The experiments are not without value, however, since they indicate the possibility that men may yet be able to work under compressed air at considerably greater depths than have yet been attempted.

Altogether, there is little in past experience which the engineer can definitely lay hold of in answer to the first two questions which we have propounded. To the third question, a somewhat

the engineering papers and resorted to the daily newspapers as a medium for publishing further claims for the design and supervision of work which are not warranted by the facts.

In the New York Sunday "Herald," of Aug. 4, he claims that the highway bridge over the Connecticut River at Middletown was built under his direction. The facts in the case are these:

This bridge was designed by the engineering department of the Berlin Iron Bridge Co., of which Mr. Chas. M. Jarvis was then President and Chief Engineer. The actual layout and design of this superstructure was done by Mr. Chas. F. Chase, who prepared all the strain sheets and estimates and designs on which the contract was taken. Mr. Tyrrell was not in the engineering department, but was making shop drawings and, in common with other draftsmen, worked on the details of this bridge. All of the field work, from the first preliminary survey to the completion of the bridge, including the details of the substructure and the supervision of the building of the substructure, and the erection of the superstructure, was under the direction of the writer, who naturally resents the impression created that he was at any time under the direction of Mr. Tyrrell.

Trusting that you will give this matter the necessary space to put this work in its proper light before the readers of the Engineering News, I remain,

Yours truly, Edwin Dwight Graves,
Chief Engineer, the Connecticut River Bridge and Highway District.

Hartford, Conn., Aug. 8, 1901.

(We have also received a letter from Mr. Chase stating substantially the same facts.—Ed.)

A Proposal for Enlarging Chicago's Business District.

Sir: We have been for the past 15 years or more reading more or less about the possible improvement of the Chicago River through the city of Chicago, which means the lowering of tunnels, lengthening of bridges, condemnation of property, clearing away improvements, etc., at some great cost. Several years ago I was in the employ of one of the principal railways then building into Chicago and it became a part of my duty to make a very thorough study of conditions as I then found them.

As we all know, the business center of Chicago is and has been in a very cramped condition, and no one going into any business there which makes it necessary to come in contact with the people would think of establishing himself north of the Chicago River, west of the canal or south of 12th St. It is no wonder that they have had to extend their limits by going into the air, but there will have to be an end to that mode of extension some time.

My idea for the relief of this condition of affairs was and is, I will admit, quite bold; but as strong medicine has to be used in obstinate cases, boldness in this case seems to me admissible.

My idea is that the canal should be moved a mile, more or less, westward. This could be done by the city first selecting some tier of blocks most available and then building all the tunnels, all the necessary bridge foundations, etc., before commencing the excavation for the canal. Then when the new canal has been constructed on lines which are satisfactory, such, for example, as are contemplated by the Federal Government, the old canal can be filled up and used as business property. It is my belief that the land so reclaimed would more than pay all the expense of the improvements. Then Chicago would have room to expand her business area to accommodate at least three times her present population, and I see no other way of her ever getting relief from her present congested state, saying nothing about the future.

If these suggestions should turn out to be of any benefit to the great city of Chicago, they are like all "good advice," free. Respectfully yours, P. F. Barr, C. E.

Phoenix, Arizona, Aug. 19, 1901.

The Resistance of Trains on Curves.

Sir: In Engineering News of Aug. 1, 1901, Mr. J. L. Campbell gives some very pertinent remarks about resistance of trains on curves, but by what process of reasoning he arrives at the conclusion that the relative length of a curve and the train have anything to do with the resistance due to curvature and therefore with the compensation, I do not understand.

The late Mr. Wellington, in his "Economic Theory of Railway Location," made a splendid analysis of the various factors which compose the resistance due to curvature and proved they were confined to the truck. There are two factors not mentioned by him which are worthy of some (generally slight) consideration. They are center and side bearing friction. The reasons why engineers have used a less compensation on steep gradient lines are two. One is that the very fact that a steep grade is required shows that every known advantage must be used to secure economical construction, and the other is that steep grades are almost invariably associated with sharp curves, and sharp curves give less resistance per degree of curvature than easy curves.

Sharp curves increase the pressure per unit of area between the wheel and the rail and thereby decrease the coefficient of friction; they also increase the velocity of sliding and again reduce the coefficient of friction between the sliding surfaces.

The compensation for curvature should be on a sliding scale beginning with about 0.04 ft., or 0.03 ft. per degree, and decrease as the degree of curvature increases.

All the experimental data I have been able to gather confirm this conclusion, but as the condition of the rail with regard to wear enters so largely into this proposition, the results do not point to any definite formula for compensation. The general tendency of modern practice is in the direction of lower compensation all along the line, one prominent Western road with easy curves using only 0.02 ft. per degree. Yours truly, L. B. Merriam.

Weston, Colo., Aug. 13, 1901.

(Proof of the above letter was submitted to Mr. Campbell, and we append his reply.—Ed.)

Sir: Referring to the enclosed criticism by Mr. L. B. Merriam of the writer's remarks on curve compensation which you were kind enough to submit for my inspection, Mr. Merriam is right and the writer stands corrected. The function of curve compensation being to attain a rate of grade on curves whose resistance shall equal that of the maximum on tangents, the rate of compensation will have no relation to length of curve. It is rather doubtful practice, however, to adopt lower rates of compensation on sharp curves, for, while they will give a lower resistance per degree when new rails are laid, the latter soon give increased resistance through greater wear more nearly proportional to the degree of curve. The tendency toward lower rates on sharp curvature is probably due more largely to the great loss of elevation entailed by a proper compensation. Yours truly,

J. L. Campbell.

Koeltztown, Mo., Aug. 23, 1901.

Subaqueous Viaducts to Cross the Hudson and East Rivers at New York City.

Sir: Ever since you described the proposed subaqueous viaduct which I am advocating as a means of crossing the Hudson and East Rivers in your issue of March 28, 1901, I have been receiving letters from engineers inquiring into details of construction, approving the scheme, or mildly, or severely relegating it to the realm of impracticability. To all of these I have written and sent such copious illustrations of that "tube" that, I think, in most cases any way, I have quieted the doubts if I have not made converts of the Thomases. Of late, however, several letters have reached me, some from your readers, that leave the technical part of the proposition alone and attack me upon the broader grounds that tunnels, or bridges, or tubes would be of no advantage to New York, as they would be impracticable, enormously expensive and serving no good purpose when completed; arguments fired at me, too, from political, civic if not civil, and other sources besides—potent objectors—the New Jersey people.

Since you were good enough to devote some space to the technical description of these "tubes," perhaps you will also give me a little more in which I may "declare my intentions," as it were. There seems to be some question about them.

No one must think for a moment that I am dunce enough to advocate the bodily transplanting of the railroad freight and passenger termini, their side tracks and yards, from New Jersey to New York, via any tubular crossings of the Hudson River. I doubt, to begin with, if Manhattan Island would be large enough for that purpose. Nor do I even suggest great passenger depots on the New York side. All I have ever thought of, or advocated, or planned for, in connection with the Hudson River were a number of subaqueous viaducts across that river from certain much-used streets on the New York side to points opposite, thus doing away with the clumsy, dangerous, slow and altogether unsatisfactory and primitive ferry service now existing.

Reliable authorities give a figure well over 100,000,000 for the number of people who cross that river, at that point, every year. As reliable railway figures give 90% of that traffic as suburban. Now, why should not a portion of this 90% at least get aboard electric cars on the New York side and go across at Cortlandt, Desbrosses, 14th, 22d and other streets, through such tubes, directly, without change, to their several destinations? Why should not those crossings serve the great stations on the Jersey side? Or, why should not the railways have some of these tubes connecting the Jersey termini with the Northern railways, so that "through" passengers might go through New York in "unbroken bulk"? Would a series of tubes somewhere up around 42d St., connecting with tunnels to the N. Y. Central tracks, be an impossible feat for our railway experts to perform? And might not those same experts devise some sort of substations on the New York side, where the ferry houses are now, mere track extensions—via said tubes—of the great Jersey passenger stations that would accommodate at least some of the 10% of those hundred million, the "sleepers," for instance.

But these are problems for railway experts. I am merely, for the nonce, a "tube builder." I simply suggest those problems. What I am after, striving for, advocating and hope to succeed in getting before I am gathered to my fathers—some time (necessarily) hence I sincerely trust—is a series of tube crossings out of New York for street traffic, surface cars, carts and foot passengers; municipal connections with Jersey City and Brooklyn, doing away with the horribly congested conditions now obtaining at the Brooklyn bridge, a shameful condition, and the prehistoric ferries and everlasting changing on the Hudson side. That's all.

Of course, the tube, sui generis, is eminently suitable for railway crossings, strong enough, infinitely cheaper and better than any bridge or tunnel (naturally, I could not resist saying that), but when I am accused of being a dreamer of crazy dreams, wishing to revolutionize railroad transportation and cram square miles of Jersey trackage into square feet available in New York, I must vociferously plead "not guilty!" F. W. Fitzpatrick.

U. S. Treasury Dept.,
Washington, D. C., Aug. 19, 1901.

A Comparison of American and British Practice in the Manufacture of Cast-Iron Pipe.

Sir: We take the liberty of enclosing you a clipping from "The Engineer," of London, which may prove of interest to you and your readers, as it was written in the interest of American exports.

It might be well to add that we are here in the capacity of sole foreign agents of the United States Cast-Iron Pipe & Foundry Co., of No. 80 Broadway, New York, and the A. P. Smith Manufacturing Co., of Newark, N. J., both of whom are advertisers in your valuable periodical.

Yours very truly, Clark-Harrison & Co.

72 Fenchurch St., London, E. C., Aug. 12, 1901.

(The clipping enclosed is as follows.—Ed.)

CAST-IRON PIPE IN THE UNITED STATES.

Sir: We have read with much interest the articles that have recently appeared in your valuable journal on the subject of "Cast-Iron Pipe in the United States," and beg leave to congratulate you on the thoroughness and correctness with which your Special Commissioner has treated the subject.

The writer has had considerable experience in the manufacture of cast-iron pipes in the States, having acted for four years in the capacity of vice-president and general manager of the South Pittsburg Pipe Works to which your commissioner refers, and it occurred to him that perhaps you and your readers would be interested in a comparison of British and American pipes and foundry practice. He has therefore written the enclosed, which you are at liberty to use as you see fit.

(1) EXTRA LENGTH.—All sizes of American pipes measure in length about 12 ft., exclusive of socket, whereas the small sizes of British pipes are only 9 ft. It is very evident that the extra length of American pipes is an advantage. The expense per length is in both cases practically the same for inspecting and testing with the hydraulic press, for transporting to the trench, for lowering into the trench, for making the joint with the necessary supply of lead and hemp, and for excavating several cubic feet of earth under the socket, so that the joint may be properly calked. There are in each mile of, say, 10-in. diameter pipes, 587 lengths of British pipes, and 440 lengths of American pipes. Hence, if the total of this expense is "B" shillings for one length of pipe, it would be per mile 587 "B" shillings for British pipes, and only 440 "B" shillings for American pipes; that is, the extra length of American pipes reduces the expenses of laying by 147 "B" shillings per mile, which is a saving equal to exactly 25% of the cost of laying British pipes. Nor is this the only advantage. In a mile of British 10-in. pipe there are 147 more sockets than in a mile of American 10-in. pipe. The socket of an average 10-in. pipe weighs 50 lbs., or more; hence, by using American pipes of the same thickness of shell, you would effect a saving in metal of 147 times 50 lbs., or about 3¾ tons in every mile of pipe purchased.

(2) TURNED AND BORED PIPE.—The only form of joint used in the United States by water-works and gas-works is the ordinary socket and spigot calked with hemp and lead. It is considered far superior to the turned and bored joint used so largely in Great Britain, for the reason that the latter fails to allow for expansion and contraction, and renders the line of pipe so rigid that the slightest settling of the ground is likely to cause either a fracture of the pipe or a leaky joint.

(3) CUTTING END OFF IN LATHE.—This is required by a large proportion of British specifications, on the principle that some slag or other impurities are invariably retained in the top of the mold, rendering it necessary to cut away that portion of the casting. In American practice it is not found necessary to cut off the spigot ends of the pipes, for reason that the iron which is used is sufficiently high in graphitic carbon, silicon, and phosphorus to render the iron mixture so fluid when in molten condition that the slag and impurities rise freely to the top of the ladle, and are not allowed to enter the mold.

The fact that American foundries have been making a satisfactory quality of pipes for more than half a century without resorting to this practice of cutting off the spigot ends, would be sufficient evidence that it is unnecessary, provided a proper quality of iron is used. Hence, why do British makers incur this extra expense in manufacturing, and so place them at a disadvantage in competing against American manufacturers?

Clark-Harrison & Co.

London, July 17.

A New Stadia Note-Book.

Sir: Having been engaged during the last year in a topographical survey covering suburban and city areas, as well as open country, the writer has read with much profit the remarks on stadia work which have appeared from time to time in "Letters to The Editor." He believes, however, that one salient feature has been neglected in the discussion of the proposed stadia field book containing a protractor page for sketching.

more satisfactory answer is possible. The broad proposition that only men whose mental and bodily functions are in healthful operation should be allowed to work under air pressure is well established. In compressed air work, as in all other cases where abnormal environment or excessive exertion task physical endurance beyond the ordinary, the man who is physically fit is the one best able to endure the strain without injury. For the same reason a carefully observed regimen of healthful diet, dress and sleep are important aids in preserving health during employment in the pneumatic caisson. A further precaution which experience has amply proved to be necessary is careful regard to the manner in which the changes of pressure upon entering and emerging from high air pressures are undergone. It is universally agreed that the change should take place gradually, so as to relieve the system as much as possible from sudden strain. It has already been noted that the danger of attack and its severity are directly proportioned to the intensity of the pressure and the length of time which this pressure is endured. From this is has come to be generally recognized that men working in compressed air must have short hours of labor, the period of labor decreasing as the pressure increases.

The remedial measures to be adopted in case of illness will now be considered briefly. Evidently the treatment will depend much upon the nature of the predominating symptoms and their severity. We also find that each physician who has studied the malady naturally suggests a course of treatment which conforms to his individual theory of the cause of the disease. Thus, Dr. Jaminet, at the Eads Bridge work, as has already been stated, regarding the affection as wholly the result of exhaustion, relied entirely upon stimulants and concentrated nourishment. Dr. Smith, at the Brooklyn Bridge work, devised a more elaborate treatment to meet his more elaborate theory. Briefly stated, he employed anodynes, generally morphine, to deaden the neuralgic pains or cramps, and administered ergot to relieve the congestion in the brain and spinal cord. These remedies were supplemented by stimulants, massage, local application, etc., as the individual case seemed to suggest. In case of paralysis the treatment conformed to the general rules applicable to this malady in any form. The treatment adopted by Dr. Wainwright and Dr. Snell, the English physicians in charge of the London tunnel work, noted in the discussion published elsewhere in this issue, appears to have consisted of the administration of ergot to relieve congestion in connection with an application of compressed air. This treatment proved so successful that it is deserving of further mention.

The compressed air treatment of disease was suggested as long ago as 1664. It seems to have been first applied to caisson disease by Dr. Antoine E. Foley in sinking the piers of the Argenteuil Bridge, France, in 1863. Dr. Foley had noticed that the neuralgic pains resulting from the malady were removed by returning the sufferer to the caisson, and he practiced this remedy in several instances. Similar observations were made by Dr. Smith at the Brooklyn Bridge in 1871-2, and he proposed an elaboration of the crude plan of returning the patient to the caisson, which he described as follows:

> Let there be constructed of iron of sufficient thickness a tube 9 ft. long and 3½ ft. in diameter, having one end permanently closed, and the other provided with a door opening inward and closing air-tight; this tube to be placed horizontally, and provided with ways upon which a bed can be slid into it. Very strong plates of glass set in the door and in the opposite end will admit the light of candles or gas jets placed immediately outside. This apparatus should be connected by means of a suitable tube with the pipe which conveys the air from the condensers to the caisson. An escape-cock properly regulated should allow the constant escape of sufficient air to preserve the necessary purity of the atmosphere within. The bed containing the patient having been slid into the chamber, the door is to be closed, and the pressure admitted gradually until it nearly or quite equals that in the caisson. This should be continued until the patient indicates by a signal, previously concerted, that the pain is relieved. The pressure should then be reduced by degrees, carefully adjusted to the effect produced, until at last the normal standard is reached. By occupying several hours, if necessary, in the reduction of the pressure, it is probable that a return of the pain could be avoided.

No opportunity was afforded to Dr. Smith to put his plan to practical test at the Brooklyn Bridge work, and so far as we know its first actual application to the treatment of caisson disease, neglecting the early crude attempts of Dr. Foley, was made on the Hudson River tunnel work in 1890. The so-called "compressed-air hospital" for this work was fully described in Engineering News of June 14, 1890. It was probably upon this work that the contractors for the London tunnels previously mentioned modeled their compressed air chamber for the treatment of caisson disease. As, already stated, its success seems to have been so remarkable as to merit for it the careful consideration of engineers.

Turning now to the concluding question in our list, it is evident that it is best answered by a brief narration of the conditions which have accompanied a few selected examples of notable compressed air works. As stated in the discussion printed in another column of this issue, in sinking the pneumatic foundations for the Glasgow bridge a maximum depth below water level of about 98½ ft. was reached, requiring an air pressure of from 43 lbs. to 44 lbs. per sq. in. to restrain the inflow of water. These figures are high, but they are not the highest which have been recorded. So far as we know, the highest air pressure in which men have ever labored in engineering work was recorded during the construction of the East River Gas Tunnel at New York city. The greatest depth below water level at which this work was prosecuted was 120 ft., requiring a pressure of nearly 52 lbs. per sq. in. to keep the heading free from water. In sinking the pneumatic caisson foundations for the Eads Bridge at St. Louis, Mo., a depth of 109 ft. 8½ ins. was reached, necessitating work under an air pressure of slightly over 47 lbs. per sq. in. Up to the present time this work records the greatest depth at which pneumatic foundations have ever been constructed, but a close approach to these figures was made in founding one of the caissons for the Brooklyn tower of the new East River bridge at New York city. In this instance the work of excavation and of placing the concrete was performed at a depth of 108 ft. below water level, requiring an air pressure of 46½ lbs. per sq. in. It is quite likely that there is on record other instances where higher air pressures have been required than were employed at the Glasgow Bridge, but the ones mentioned are the most notable. The effect upon the workmen in each of the cases mentioned will now be referred to.

In the East River Gas Tunnel works, in spite of a careful physical examination of the workmen prior to their admission to the air lock, 15 of them suffered more or less from caisson disease, and there were four fatal cases, death being due to carelessness in leaving or entering the lock. The usual working hours were six, reduced to two hours as the pressure increased, alternating with two hours' work outside before entering again. In the Eads Bridge work there were 77 cases of caisson disease developed, eight of which were fatal to the sufferers. The precautionary and remedial measures adopted comprised a physical examination and the routine administration of stimulants and beef tea. At the new East River bridge there were only a few cases of caisson disease, and these were so mild in character that a rigorous massage was sufficient for complete recovery. From the time the work reached a depth of 100 ft., however, considerable difficulty was experienced by the engineers in securing laborers who were physically fit and at the same time willing to work in the caisson. At the maximum depth of 108 ft., it was possible to work the men only two shifts of 45 mins. each during the 24 hours. Except for care in selecting the men, the only precautionary measures practiced were to provide a warm room and warm baths for them upon leaving the caisson and supply them with plenty of strong coffee. At the New York & Brooklyn Bridge work the air pressure employed was 36 lbs. per sq. in. During this work there were 110 cases of caisson disease, of which 13 were serious, being accompanied by paralysis, and three were fatal.

This narration of representative examples appears to fairly establish the limit of pressure at which work in compressed air can be performed.

Possibly somewhat greater depths may be attained in the future, and the Hersent experiments above noted give some encouragement in this direction. The above quoted experience indicates, however, that even though work may possibly be carried on at these greater depths, the risk involved, the very short period of work possible and the high wages that must be paid, will make such works financially impracticable in nearly all cases, even though their accomplishment be theoretically possible.

To summarize, the question may be asked: What, taking it altogether, does past experience in compressed air work teach the engineer regarding the occurrence and treatment of caisson disease? Briefly stated, it teaches that comparatively few engineering works in which air has been used at pressures exceding 35 lbs. per sq. in. have been free from the ravages of caisson disease; that the cause is not fully determined and agreed upon by physicians, and, consequently, that it is impossible to know whether or not it is a necessary and inseparable condition of work under compressed air, and, finally, that there are available a number of fairly successful precautions and remedies against the disease.

LETTERS TO THE EDITOR.

A Comparison of Concrete and Stone.

Sir: In connection with letters recently published concerning the use of monolithic concrete, the results of an investigation recently made for the company with which I am connected may be interesting to some of your readers.

We received letters from several engineers who have had considerable experience in the use of monolithic concrete. The substances was, that it is a good substitute for cut-stone work where the price of such work is high, and that it could be used satisfactorily in all ordinary railroad structures when made of the best Portland cement, with a competent inspector at each structure during the entire time of construction and with frequent tests of the materials. We examined a large amount of such work near Chicago and concluded that very stiff special specifications were necessary, that it was good practice to omit projecting copings, to step wing walls instead of sloping them, and to use moldings and avoid sharp edges. Estimates made for a 15-ft. arch showed that at that place the cost was the same for a concrete arch without steel and for a stone arch with first-class sheeting and second-class bench walls. It is hardly necessary to say that the stone arch will be built. Since there seems to be such a diversity of opinion as to the advantage of using wet or dry concrete and screened stone and the results of tests made show such conflicting results I think it best not to enter into any discussion on those points.

Yours respectfully, C. A. Fowler.

Columbus, O., Aug. 19, 1901.

Stresses on Dams Due to Impact.

Sir: Mr. H. P. Gillette, in an article upon dam construction, in your issue of May 30, remarks:

> One writer says that since the velocity at the center of the stream is greater than at the sides, a greater pressure must exist upon a dam at that point. It would be well if those formulating theories would express themselves in numbers.

I have at different times put forward the theory that there are unequal loads upon a dam, and I do not think it will be very long before there will be others who will hold the same opinion.

I have seen the Monongahela and Ohio Rivers at Pittsburg in flood, when the logs and debris made a continuous line down the center of the river, and even included a two-story house. Any such floating mass would hit an overfall dam on the crest and exert a large leverage to overturn it. Such a blow would occur at the center of the river, where the current has the greatest velocity.

Take, again, the case of an ice floe, say 40 ins. thick, with say, 36 ins. below the surface in a flow of 24 ins. of water over the dam and extending back in a straight line 200 ft. or more. Such a body, at 10 ft. per second, would give 412,500 ft. lbs. per lin. ft. for each foot in length of the crest, and for 50 ft. width of floe it would give 2,062,500 ft. lbs. That is a serious enough blow, but its great leverage to overturn the structure makes it still worse. As for the blow delivered, it may be the amount required to crush ice or to deflect it up and over the crest, but such a blow must be a severe one, and it is an unequal load, and a series of them striking at different points would constitute a moving load.

I have advocated a dam shaped in plan like a Warren girder, and have given figures to prove that by this means a factor of safety of 5.4 can be obtained as easily as a factor of 2 is obtained in the old way. Yours truly,

John S. Fielding.

P. O. Box 512, Sydney, N. S., July 28, 1901.

Credit for the Design of the Connecticut River Bridge at Middletown.

Sir: Since the publication of facts by the Boston Bridge Works, in Engineering News, of June 27, 1901, in regard to the origin of plans for engineering structures published by Mr. H. G. Tyrrell, he has evidently deserted

was caught by a cushion of water whose upper surface was fully 25 ft. above the datum zero (the upper surface of the toe). The velocity of the water below the dam in the main stream was not 20 ft. per second, and that near the toe could not have been that much. The velocity due to fall was largely destroyed by the impact on the water below the dam. Having been an eye-witness of the flood of June, 1900, when the lake level was 9.8 ft. above the crest of the dam, and having seen the dam during all of the floods (save one) since its completion, and having heard from eye-witnesses of the failure in April, 1900, I can state that when the water was 4 ft. deep on the crest, the sheet of water in its fall did not conform to the configuration of the dam, but left it a few feet below the crest. At high floods the major portion of this sheet fell clear of the toe, or rather would have done so if permitted to reach that level.

Having read all of the reasons assigned for the failure, having studied the dam from the time the first stone was laid till its completion, having sounded in the tail race and later in the foundation, I am firmly convinced that failure was caused by a poor foundation. With nearly all of the letter of McCarty & Son I agree. That the toe should have been let deeper into the bedrock cannot be doubted. From surveys made before construction it was concluded that the low-water level below the dam would be even with the upper surface of the toe, but floods during construction so modified the channel that the low-water level was fully 2½ ft. below the top of the toe. At no time during the life of the dam did I witness the water's passing off the toe in a gliding sheet.

That the dam failed by sliding is well established. The first of the series of events that commenced at 11.20 a. m. on April 7, 1900, was an opening in the dam at a point about 350 ft. from the east end; then two pieces about 250 ft. long moved like the two halves of an immense double gate, both halves being torn from their hinges and moving down stream to a position in the old tail race. The cause of the sliding was a lack of sufficient connection between the dam proper and the foundation bed. The foundation in the locality of the break was a friable limestone, and toward the eastern portion a fault 75 ft. wide, composed chiefly of clay with loose boulders, was encountered. The foundation of the whole eastern portion was nowhere first class. Mr. Frizell intended to carry out a supplemental work of protection below the dam in the form of a reinforcement of the bed of the tail race.

Being the author of "Water Supply and Irrigation Paper No. 40," issued by the Hydrographic Division of the U. S. Geological Survey (referred to in the foregoing letter) I utilized every available source of information, including correspondence with the engineers of construction, and I now state after reading all that has been advanced that I certainly would not class the cause averted to by Messrs. McCarty & Son as "one of the most potent forces which compassed its ruin." Their conclusions for the conditions assumed are correct, but these conditions did not obtain at the Austin dam. The primal cause of failure was a bad foundation originally, which was permitted to become worse. Yours truly, Thos. U. Taylor.

Austin, Tex., Aug. 18, 1901.

What Shall Fix Fair Wages?

Sir: In your issue of Aug. 1, 1901, appears an editorial entitled "What shall fix fair wages?" In this appear some doctrines which I think should not pass unchallenged. If I understand your position, you defend the labor union on the ground that without it the men could not be sure of fair wages, and you oppose the piecework systems because they are productive of competition among the laborers. Towards the end of your article, however, is the statement "a fair return for capital in the steel industry (or other non-competitive industries) is such a return as is received by capital under a similar risk in freely competitive industries." If competition furnishes the proper basis for estimating a fair return for capital, why is it not satisfactory in determining a fair return for labor? It seems to me that in this case "sauce for the goose is sauce for the gander." You say also that "the worker demands that he be given a voice in fixing his own compensation and terms of employment." He has it and in the absence of a legally-authorized slavery system he cannot be deprived of it. I have never heard of an employer who attempted to deprive an employee of this privilege. What most employers do object to, however, is conceding to John Smith, laborer, "a voice in fixing the compensation and terms of employment" of Wm. Jones, laborer. This is what the "worker" demands.

The labor union is essentially an organization for interference with other people's business. Its avowed purpose is to obtain for its members the maximum wages in return for which they shall give the minimum of labor. It is free enough in fixing minimum wages which the employer must pay, but it not only does not fix a lower limit to the day's work which the laborer must accomplish, but it objects very strenuously to the employer doing so. The union does not make any distinction between skillful and unskillful, industrious and lazy. It objects to such a distinction being made by anyone. It opposes piecework because this system shows up impartially the good and the poor workmen. A strike which resulted in the destruction of property and the loss of some life recently occurred in this state because under a contract system by which skillful, industrious men earned 20% to 30% more than the union wage, the management refused to guarantee the union wage to all the men. Such a system accomplishes the very desirable end of forcing out the unskillful or lazy man and leaving his skillful and industrious associates. In the course of time a still further differentiation will take place and the best among the men eventually reach the top while the others are strung out along the road in positions determined by their abilities and energy. Honest, competent men have no need to organize a union. The union system attempts to raise all of the men or, failing that, to keep down the few who are capable of rising. As the men are not and cannot be all equal in the qualities which are of value in great industries, the attempt to raise everyone fails as a matter of course. The other alternative is to prevent anyone from rising, and this is accomplished.

The system of paying on a time basis has been so long in use that it has come to be regarded as the only fair one, and other systems are judged by comparison with it. As a matter of fact a workman's time is of no value to his employer. What is wanted and what is paid for is the work accomplished in that time. Payment on the time basis implies two things, viz., that the workman is thoroughly competent in all respects and that he makes an honest effort to accomplish as much as possible in the working time. It is seldom that either condition is fulfilled. The piecework plan, of which there are numerous modifications, is fair for all parties concerned in that a man is paid in direct proportion to the value of his services to his employer. Everything else is sold on that plan; why not labor? Imagine a householder contracting with a grocer to furnish whatever provisions the said householder may require at a fixed price per month. Both parties would sit up nights devising plans to gain an advantage and spend their days trying to put the plans into execution. The grocers would probably form a trust, while the householders would organize a union, and between them the courts would be kept pretty busy. By the time one court has enjoined the householders from receiving any provisions and another had issued an order to restrain the grocers from collecting any money for the provisions delivered we should have an approximation to the present chaotic condition of the labor market.

So much for the system of payment and its relation to the union. The unit upon which the system should be based is another matter. How much per day or how much per piece is a man to receive? Quoting from your editorial: "What are fair wages for the steel workers? They are such wages as are received by workers of similar skill engaged in work of approximately the same general desirability, in industries where free competition prevails." This seems to me to be begging the question.

Suppose—and the possibility is not very remote—that there are no such industries?—that every one of them is controlled by a trust. What then becomes of your basis for fixing wages? Even if one industry remained on a competitive basis the wages paid to the steel workers would be determined by the condition of this one industry at the time when the wage scale was fixed. Is there any good reason why a steel worker's pay should go up and down with the variations of the labor and merchandise market of the glass business, for example?

There is only one fixed point in a wage scale, viz., the minimum. This is the least amount on which the workman can maintain health and strength. Should wages become less the mills must stop for lack of labor. Above this point the pay is determined by the law of supply and demand. In civilized countries wages tend toward the minimum. The older and more advanced the civilization the nearer the wages approach the limit. There is at least partial justification for this in the fact that permanence of employment is more nearly assured in the more developed regions. In many of the mining districts of Europe an able-bodied miner receives from 60 cts. to 75 cts. per day. Among these people it is customary for a man's wife and those among his children who are old enough, also to work in or about the mines. In this way the aggregate wages of the family are sufficient to support it. In America our semi-savage condition has so far prevented us from putting the women and children to this kind of work, and the wages paid to the individual laborer are somewhat higher—sufficient for himself and his family. It is common to hear in reply to such statements as this that the laborer wants and is entitled to more than a bare living—that he should have some of the luxuries as well. How many? Does he want pie on Sunday or a steam yacht? Where is the line to be drawn and who is to draw it? One end of the graduation of the wage scale of the world is the bare living received by the least important member of society. The common laborer may make up his mind that he is that least important member. If he wants his compensation increased, let him cut loose from his union and show himself willing to do all he can, and, second, capable of doing more than his fellows. Some day then he may be worth as much as the president of the United States Steel Corporation. A loud clamoring that because he is on earth he is of as much importance as anyone will not help him.

In conclusion, I do not believe there is any tenable ground between the absolute control of a business by its owner and the co-operative system which is advocated by many socialists as a cure for all existing evils. Even this latter system would not be free from labor troubles, for there must be a head and a control, and those at the bottom of the ladder would be sure to think themselves oppressed. Yours truly, Charles W. Comstock.

Denver, Colo., Aug. 19, 1901.

(Our correspondent ably presents one side of the labor question; but our attempt in the editorial to which he refers was to show how the case looks from the laborer's standpoint, as well as from the standpoint of the public at large.

Many things which our correspondent says are entirely correct; but his statement that the rate of wages will be raised, by the law of supply and demand, above "the least amount on which the workman can maintain health and strength," seems to us by no means self-evident. The law of supply and demand may operate when free competition prevails; but when a trust controls an entire industry, are not the workers reduced to the alternative of accepting such wages as the trust offers or remaining idle? Are they so much to be blamed under such conditions for opposing monopoly to monopoly?

Further on our correspondent argues that in the highly civilized countries of Europe child-labor and female labor in and about mines is commonly employed, and declares that only the "semi-savage condition" of America prevents its use here. If this is true, then may we long remain a nation of semi-savages!

We maintain, on the contrary, that the abandonment of child-labor and female labor marks an advancing civilization. The most advanced states, Massachusetts, for example, have done most to restrict the employment of women and children in mining and manufacturing industries. In England, in the early years of the century, children of six to ten years of age were employed in mines to push the loaded cars through narrow galleries, and the story of their sufferings is a tale of horror hardly equaled by the records of the Inquisition. Surely England advanced in civilization in the nineteenth century.

We may note here, too, in the summary of testimony just issued by the U. S. Industrial Commission, that the employment of children in mines and factories is deprecated by every witness who refers to it.—Ed.)

A Rational Formula for the Length of Wasteways.

Sir: Having carefully read Mr. Jos. P. Frizell's letter in your issue of Aug. 8, 1901, relative to "A Rational Formula for the Length of Wasteways," I would offer a few objections to the formula as it is given. In the first place, Mr. Frizell assumes as self-evident the propostion that

$$\frac{l_1}{l} = \sqrt{\frac{A_1}{A}}, \text{ where}$$

l = length of wasteway of an existing dam on a given stream where the depth of water over the crest has never exceeded a given number of feet, say 10.

A = drainage area tributary to the wasteway whose length is l.

l_1 = proper length of a proposed wasteway that is to have a maximum depth of 10 ft. over the crest.

A_1 = drainage area tributary to the wasteway whose length is l_1.

Even assuming that A and A_1 are on the same river valley, it is certain that unless the wasteways are very close together the assumption expressed in the above equation is far from being rational, for five reasons; first, because the intensity of rainfall over a large area is much less than over a small area; second, because the slope of a valley increases as approach is made toward the headwaters; third, because the number, location, and slope of lateral tributaries to the main valley must necessarily vary and produce in consequence great variations in maximum discharge per sq. mile at different points in the valley; fourth, because a narrowing of the valley toward its head causes a variation in the hydraulic mean radius and consequently in the rapidity of discharge of flood water; fifth, because the storage capacity of a dam with a long crest in the lower part of a valley is generally greater than a short-crested dam farther up. Other factors that make apparent the error of Mr. Frizell's assumption might be enumerated, but I have given enough. Yours truly,

H. P. Gillette.

Rochester, N. Y., Aug. 10, 1901.

Sir: The writer is interested in the "Formula for Length of Wasteways," by Mr. Frizell, appearing in your issue of Aug. 8, which seems to be a neat method where an existing dam and spillway, by long service, have proved

In any thickly-settled region there are usually sufficient minor details so that for the territory which one sketch covers there will be several pages filled with recorded shots, remarks, etc. If the sketch is made by the recorder upon a regular-sized page, or even upon a regular double page, he must waste much time flipping the leaves of his book back and forth. He must flip a leaf or several leaves between the recording and the plotting of each shot, since there are usually several pages of recorded shots to each sketch. To obviate this, the protractor or sketching page should be bound in the back of the book in such a manner that, when the book is shut, the sketch may be unfolded so as to open out and lie in full view of the sketcher.

When the map is developed by the draftsman, the sketch should likewise be in full view while the shots on the respective pages are being plotted; and this cannot be, if the sketch is on a regular sized page and at the same time pertains to several pages of recorded shots.

Many engineers object to having sketches made upon loose sheets, fearing that important data may be lost; but at present we find it profitable as a time saver and we get better sketches by fastening a loose protractor sheet or page upon a sketching board. When the sketch is finished, it is pasted to the outer edge of the right-hand page, opposite the last left-hand page of recorded data which pertains to that sketch. The sketch may now be folded in the book or lie open for the draftsman's reference while he plots the shots recorded on previous pages.

In brief, the advantages gained by this method are:

(1) The sketch can be made to any scale desired. This is especially to be sought after in suburban districts where much construction is in project, because here two kinds of maps may be desired from the survey notes, viz.: large-scale detail sheets, and one complete smaller scale map of city and surroundings. In such cases, it is advisable to have the sketch to as large a scale as the detail sheet is to be; for a reduction of scale in plotting is preferable to an enlargement. A large-scale sketch, also, gives a more efficient check to the instrumentman.

(2) No time is wasted in juggling the pages of the field book.

(3) The sketch may always be in full view of the sketcher and later, of the draftsman, while he is reducing his notes and plotting.

It may be of interest to state that the writer's experience is that in thickly-settled regions, suburbs, etc., an expert instrumentman with four or five quick-footed stadiamen can take shots at such a rate that the speed of the party depends upon the speed of the recorder, while another man is kept busy sketching as closely to scale, and in such detail, as the nature of the survey demands.

Very respectfully, Tachymeter.

Havana, Cuba, Aug. 16, 1901.

(In the book which we have now in preparation, there is room for recording 40 shots on a single page, and this is surely as many as should be plotted on a single protractor page. If not, they can be plotted just as well on the next page and just as readily transferred to the map from two or more sketch pages as from one. Probably our correspondent has plotted only a few of the shots taken, in which case, as he says, one sketch page might be used to several pages of notes; but with the book in question it is easy to plot every shot, and there appears to us to be a manifest advantage in having the note page and sketch page always opposite each other, so that one serves as a check on the other, and errors are pretty certain to be discovered.—Ed.)

Is Smelting of Iron Ore by Electricity Practicable?

Sir: You were so good as to print a letter written by me upon the above named subject in your issue of Aug. 22. To the letter, as published, I have nothing to add, nor do I desire to alter one single statement contained therein, notwithstanding you have done me the honor to adversely criticise certain of the figures given and certain of the claims made. The question being discussed is of such importance to those interested in the iron trade that I feel sure you will permit me to reply to the criticism.

Your very proper warning in reference to the computation of the annual cost of hydraulic and of electrical horse-power I freely admit to have been well taken, although it cannot apply in my case. I freely admit that in the past companies owning hydraulic and electrical plants have been ruined, owing to the fact that little and in some cases no depreciation had been allowed for. This is no novelty in the world's history; but because others have neglected to allow in their calculations a sufficient sum to cover the depreciation on their plant, is that any proof that I have not made a sufficient allowance? Speaking generally, the power houses which are at the present time being erected, or which have lately been erected, are of very different character from those which were built years ago. In no business so much as in the power business is it necessary that each plant should be considered by itself, when the amount to be allowed for depreciation is to be fixed.

The amount to be allowed for depreciation must vary, according to the quality of the work, the nature of the work, the height of the fall as used, the speed at which the machinery is actuated, the nature of the turbines, whether vertical or horizontal, the care taken of the machinery, the risk of damage from floods or from ice, cheap construction generally entailing a greater risk of loss from depreciation.

When concrete construction has been adopted, and when the work has been executed under competent supervision, the depreciation of the hydraulic development (outside the machinery) should be under ordinary conditions very small. The value of the water power privilege does not decrease, but is likely to increase. Depreciation of the engineering work, such as excavation, does not of course exist. That of the superstructure is not more than that of ordinary buildings, if so much. The depreciation to which the turbines are liable depends chiefly upon the height of the fall and upon the speed at which they are run. I have known turbines doing good work for 20 years and were not then worn out. The depreciation of the electric generators depends largely upon the size of the units used, the speed and the voltage at which they are run. But I see no reason why generators, as now made, should not be in commission at the end of 20 years. Much of the trouble and loss which has been experienced in the past by the users of electrical machinery was not caused by fair depreciation of the machinery, but by the owners' mistakes and lack of knowledge.

Suffice it to say that I believe in allowing in all my calculations a sum ample for depreciation, and that I have done so in this case, when I based my calculation for electrical power at $10 per E. HP. per year.

You object to the claim made by me that the plant used by an iron smelting works where electricity is used instead of coke is less costly than the plant where coke is used. Permit me to point out that the cost of the hydraulic and electrical development necessary to provide the electricity has nothing to do with the cost of the smelter plant. The cost of the hydraulic and electrical development has no more to do with the cost of the smelter plant using electricity than has the cost of the coal mines, connecting railways and coke plant to do with the cost of the smelter plant using coke.

You further state that $100 per HP. is "a very low figure" for an electric plant. I regret that I am obliged to contradict you. One hundred dollars per HP. is not a very low figure. It is the average figure at which power plants have been developed, which power plants were developed, not because the power was one which could be developed cheaply, but because it happened to be situated near to a large center of population or where steam power could only be generated at a very high cost. Electric power can be developed at a cost as low as $40 per E. HP., and with this cost the annual rental, at $10 per year, is amply large enough to allow depreciation, as well as a good interest return upon the investment.

I am informed by an electrical engineer that electric furnaces of the size and number necessary to smelt 150,000 tons of iron per year would cost, with appliances, $300,000. Suppose, however, that they cost $500,000; their cost would then be one-half the sum you admit the old style costs. Further, you state "as no such furnaces as yet exist," and upon this supposition base an argument. Your statement, not being correct, your argument must of necessity be valueless. I have before me a copy of an "Extract from the yearly report of a Society of Applied Chemistry," in which one of the members describes the working of three electrical furnaces working at a place named, each furnace being of 500 E. HP., and which together produced 4,000 tons of steel per year. The report then states: "Furthermore, iron and steel can be made of any desired percentage of carbon as well as of alloys—all in one operation."

I am informed that other electrical furnaces are also successfully at work in Europe, as well as on the Continent. For your information I would state that I am credibly informed that electric furnaces, making calcium carbide are working, which upon testing, have given an efficiency of 97%, including the loss in the transformers used.

Having applied to all your objections and criticisms, and having shown that they were not well taken, I believe I can justly claim that, providing the quality of steel produced is found to be marketable, that it is practicable to smelt iron ore by electricity. I am yours truly,

Louis Simpson.

Victoria Chambers, Ottawa, Ont., Aug. 26, 1901.

(Our correspondent is correct in saying that the cost of the hydraulic and electric plant necessary to furnish the electric current should be considered independently of the cost of the smelter plant itself. We showed in our original article that the coke required to make a ton of iron cost about $2, and that to furnish as much heat as the ton of coke furnishes would require about ⅕-HP. of electric current acting continuously, day and night, for a year.

As to the efficiency of the furnace, the figure of 97% efficiency for the calcium carbide furnaces means that 97% of the current is converted into heat at the terminals in the furnace. It does not mean that 97% of the current energy is actually absorbed in causing the chemical combinations, whereby calcium carbide is produced. There are large losses of heat by radiation and conduction from the furnaces. In fact, no furnace ever made, no matter what its method of heating, is or can be free from such losses.—Ed.)

Another Communication on the Failure of the Austin Dam.

Sir: One of the subjects of greatest interest to readers of the Engineering News which has been treated or referred to in your valuable journal during the past fifteen months, was the failure of the Austin dam on the Colorado River, which occurred on April 7, 1900. Some of the more important facts, which served to intensify this interest in the subject, may, briefly, be recapitulated as follows: (1) It being one of the highest dams in the United States, over which freshet floods flowed. (2) Because some of the most distinguished engineers in this country had been engaged upon it, at different times, and (3) because it had cost the city of Austin more than $1,000,000, besides the loss of life and property, which occurred when it failed.

More recently, as you are aware, the U. S. Geological Survey has published, under the head of "Water Supply and Irrigation Papers," No. 40, what may be termed an official report upon the whole subject of construction and failure of this dam. After carefully reading this report the writer was not a little surprised to find that no reference is made therein, to one of the most potent forces which compassed its ruin.

It is a well-known principle of hydraulics, that water flowing swiftly by a submerged orifice, will exhaust the water as well as the air, from the interior of the tube, receptacle or reservoir to which such orifice is an outlet.

The fact that the erosion, caused by the water flowing along the toe of the Austin dam, produced an undermining and excavation at that point to a considerable depth, is undisputed. Cashier Palm certified that he ran his fishing pole under the toe, to the distance of 6 ft., as early as 1897.

Then, too, so far as we are able to judge from the cross section, the toe on its down-stream face had a perpendicular surface of about 5 ft. There would, therefore, be a portion of this surface, as well as all of the under-surface of the toe, which may have been exposed by the undermining, subjected to the force which would be produced by a vacuum at the lower line of the dam.

After making due allowance for friction on the apron, to compute the velocity of the water at the foot of the dam, when flowing 10 ft. deep, over its crest, at 3,000 ft. per min., would be a conservative estimate. Engineers who have experimented along this line will agree that, if the water attained a velocity over the toe of the dam of, even, 2,500 ft. per min., every particle of air from the cavity under, and about the toe, was exhausted in a very short time.

Such being the case, the resultant force to cut the bed joint of the dam would be equivalent to 30-ft. head of water, and as no rubble masonry is without voids, or unfilled spaces, in its make up, the interior body of the structure was subject to this force. So that, at the instant of failure of the Austin dam, the combined resultant forces operating to cut the bed joint, was equivalent to nearly 100-ft. head.

As further proof of this statement, it is in evidence that when the two sections of about 250 ft. each moved down stream about 60 ft., being no longer subject to this additional force, the sections stood upright, when not only resisting over 60-ft. head of water; but the additional power of that water in motion, as well.

In closing this note, we beg to suggest that excavation should have been made for the toe at time of construction, and its upper surface brought almost down to the grade of the river bed. Yours respectfully,

McCarty & Son.

Sandy Hill, N. Y., Aug. 6, 1901.

(We submitted a proof of the above letter to Prof. T. U. Taylor, of Austin, who has contributed several papers to our columns on the Austin dam failure, and he has favored us with the communication below.—Ed.)

Sir: In commenting on the letter of McCarty & Son, it must be admitted that all of the general statements as to the dam, its height, cost, etc., are well known. The effect of the water's flowing by an orifice no one will question, but this condition did not obtain at the Austin dam during high floods. The flood discharge did not glide off the toe as it was supposed it would when the cross-section was determined. It was a pioneer dam for flood streams. The outer sheet of water at high flood, if it had been permitted to reach the bedrock, would have fallen several feet below the toe down stream. However, the water

gives a flow of 1,015 cu. ft. per second per square mile from an area of 3.6 sq. miles on the same stream as the last. Our formula gives

$$17.35\sqrt{\frac{8,006}{3.6}} = 818.$$

AREA OF ABOUT 20 SQUARE MILES.—Mr. Kuichling gives for the Landwasser in Saxony a flow of 365.9 cu. ft. per second per square mile from an area of 20.1 square miles. Our formula gives

$$17.36\sqrt{\frac{8,006}{20.1}} = 346.$$

AREA OF ABOUT 100 SQUARE MILES.—Mr. Kuichling gives for the Quela River in Germany above Marklissa, a flow of 205 cu. ft. per second per square mile from an area of 116 square miles. Our formula gives

$$17.35\sqrt{\frac{8,006}{116}} = 144.$$

AREA OF ABOUT 400 SQUARE MILES.—Mr. Kuichling gives for the Kinzig River at Orlenburg a flow of 100.5 cu. ft. per second per square mile from an area of 386 square miles. Our formula gives

$$17.35\sqrt{\frac{8,006}{386}} = 79.$$

AREA OF ABOUT 1,000 SQUARE MILES.—For the Raritan River, near Bound Brook, N. J., Mr. Kuichling gives 59.3 cu. ft. per second per square mile from an area of 879 square miles. Our formula gives

$$17.35\sqrt{\frac{8,006}{879}} = 52.4.$$

AREA OF ABOUT 5,000 SQUARE MILES.—The flow of the Merrimac at Lawrence, with a depth of 10 ft. on the Lawrence dam is at the rate of

$$\frac{3.09 \times 10 \times \sqrt{10 \times 900.}}{4,600} = 19.12$$

cu. ft. per second per square mile. Our formula gives

$$17.35\sqrt{\frac{8,006}{4,600}} = 24.2.$$

This is given as in duty bound, though it is no very striking confirmation of our proposition. It is to be remarked, however, that the floods of the Merrimac are naturally modified by the great lakes in the upper part of the valley, a feature almost wholly wanting in the Connecticut valley.

AREA OF ABOUT 10,000 SQUARE MILES.—The 10th U. S. Census Report gives the maximum flow of the Potomac at Great Falls, where the drainage area is 11,476 square miles, as 175,000 cu. ft. per second. It is presumed this result was arrived at by the U. S. Engineer officer in charge of the Great Falls dam. It is at the rate of 15.2 cu. ft. per second per square mile. Our formula gives

$$17.35\sqrt{\frac{8,006}{11,476}} = 14.5.$$

It must be observed that both Mr. Kuichling and the Tenth Census Report give some results so utterly abnormal that they are disregarded.

AREA OF ABOUT 30,000 SQUARE MILES.—The Colorado River above the city of Austin, Tex., has a drainage area of about 32,000 square miles. Its aggregate flow per square mile is probably less than a tenth that of the Connecticut at Holyoke. From the cross-section and slope of the stream it was computed that, in the memorable flood of July, 1865, it carried 250,000 cu. ft. per second, being about 7.8 cu. ft. per second to the square mile of drainage area. Our method gives

$$17.35\sqrt{\frac{8,006}{32,000}} = 8.7.$$

AREA OF ABOUT 1,000,000 SQUARE MILES.—The greatest discharge of the Mississippi River found by the Mississippi River Commission at Memphis, Tenn., was in 1882, viz., 1,835,000 cu. ft. per second.* The drainage area tributary to this point is given by Humphrey and Abbott,† as 930,000 square miles, making the flow at the rate of 1.97 cu. ft. per second per square mile. Our formula gives

$$17.35\sqrt{\frac{8,006}{930,000}} = 1.60.$$

Since the above was in type, I learn from Col. Amos Stickney, President of the Mississippi River Commission, that the Commission regards the discharge measured at Warrenton, near Vicksburg, April 15, 1897, as the maximum flow of the Mississippi. This was 1,777,000 cu. ft. per second on a drainage area of 1,116,430 square miles, being at the rate of 1.59 cu. ft. per second per square mile. Our method would give

$$17.35\sqrt{\frac{8,006}{1,116,400}} = 1.47.$$

The next highest result given by Colonel Stickney is the result at Arkansas City, May 4, 1892, viz., 1,742,000 cu. ft. per second from 1,102,600 square miles being 1.58 cu. ft. per second per square mile. Our method gives

$$17.35\sqrt{\frac{8,006}{1,102,600}} = 1.48.$$

The next was at Columbus, Ky., Feb. 22, 1882, viz., 1,603,000 cu. ft. per second from 895,550 square miles being 1.79 per square mile. By our method

$$17.35\sqrt{\frac{8,006}{895,550}} = 1.64.$$

It appears to me from the foregoing that the formulas

$$l_1 = l\sqrt{\frac{A_1}{A}} \text{ and } q_1 = q\sqrt{\frac{A}{A_1}}$$

must be admitted as presumptions of science though subject, like presumptions of law, to control and modification by evidence of exceptional conditions in the case to which their application is proposed.

J. P. Frizell.

60 Congress St., Boston, Aug. 22, 1901.

*Report of Chief of Engineers, 1890, p. 3,220.
†Delta survey, 1861, p. 136.

Notes and Queries.

"Eccentric," Lomagunda, Rhodesia, writes:

In making mine surveys I use a transit with an eccentric telescope, and when reading horizontal angles, a correction has to be made for the deviation of the line of sight from the center of the instrument, the telescope moving tangentially on a small circle of a radius equal to the eccentricity of optical axis from axis of instrument. Can you give me a quick and accurate method for making this correction?

Stanley in his treatise on "Surveying Instruments," advises that the eccentricity be compensated for in the plotting by making each transit station a small circle with radius equal to the amount of eccentricity, plotted to scale. The angle may then be plotted tangential to this circle. Johnson in his "Theory and Practice of Surveying" remarks that the azimuth read must be corrected by an angle whose sine is the eccentricity of the telescope divided by the horizontal distance between the stations. He also gives further detail instructions for the use of the instrument which space forbids our reproducing here.

NEW HYDROGRAPHIC CHART ENGRAVING MACHINES FOR THE JAPANESE NAVY.

We illustrate in the accompanying cuts three of the elaborate set of hydrographic chart engraving machines, which have been built by Queen & Co., of Philadelphia, Pa., for the hydrographic office of the Japanese Navy. These machines are identical with those made for the U. S. Hydrographic Office and the U. S. Coast Survey, and are the invention of Mr. Vincent Le Comte Ourdan, who was for 19 years engraver in the U. S. Hydrographic Office, where he created the Section of Mechanical Engraving, of which he was chief until his recent resignation for the purpose of going to Japan to deliver and install the machines illustrated.

There are now in use in the U. S. Hydrographic Office two sets of these machines, and while they do not engrave quite one-half of the entire chart, they have, according to the official report of the Hydrographic Office, trebled the output of charts. The machines, of which there are six, consist of a sounding engraving machine, a combination of tinting and border engraving machine, a border subdividing machine, a border and scale shading machine (which also engraves the U. S. Hydrographic Office symbol of mud bottom), a compass engraving machine and multi-point divider.

The sounding machine (Fig. 1) is 10 ft. in length by 4 ft. 6 ins. in width; its great length permits the original drawing and the plate, which is to be engraved, to be placed side by side on the table. The positions of the soundings are then transposed from the original drawing to the copper plate by means of a crosshead, which travels north and south carrying two carriages, which travel east and west, each in an opposite direction to the other; the one over the drawing carrying a stationing point which is always in contact with the surface of the drawing, the other carrying the engraving mechanism and a set of patterns which are engraved on a circular disc mounted on the top of the carriage. At the lower part of the carriage there is a universal joint through which passes an engraving tool long enough to reach from the plate to the pattern disk.

The position of the sounding desired to be engraved is obtained by moving the crosshead north or south and the carriages east or west until the stationing point is over the first figure of the sounding to be engraved. The pattern disk is then rotated until the proper numeral is brought to the index point directly in front. The engraving point, which is heavily weighted, is then lowered to the plate and the upper end is made to follow the channel of the engraving pattern, thus cutting the numeral in the copper plate. This operation is repeated until all of the soundings are engraved. The depths of the lines are regulated by the amount of weight on the engraving point, and the size of the figure engraved is regulated by raising or lowering the universal joint. To compensate for the shrinkage or expansion of the drawing, the stationing point has a movement independent of the engraving point, and as the engraving point travels north and south or east and west, the stationing point is moved in the reverse direction by its independent movement, thus distributing the small error due to shrinkage or expansion over the entire chart so that at no one point is it noticeable.

The border engraving machine (Fig. 2) is designed for engraving border and scale lines, which are afterwards divided into degrees, and, by the border subdividing machine, are then subdivided into minutes or seconds. The border engraving machine consists of a long track of two parallel bars on which moves, on anti-friction rollers, a carriage carrying either a graver or a roulette, the former for the engraving of long straight lines, the latter for the drawing of long dotted lines. In both cases after each line is cut the tool is shifted laterally by means of a micrometer screw with pawl and ratchet the distance required between the lines for borders. The fine lines are first cut under light weight, then the black part of the border is cut under heavy weight, and consists of a series of lines so close together that they practically run into each other, giving a smooth broad line, the bottom of which is corrugated and well adapted to hold the ink for printing. In tinting,

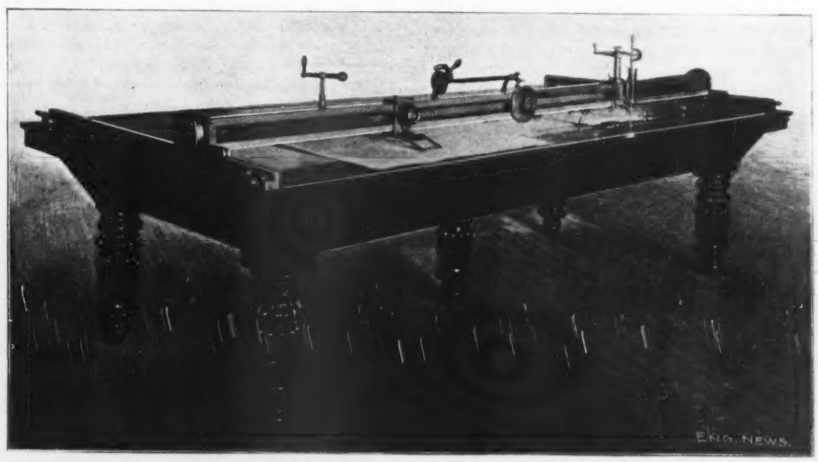


FIG. 1. MACHINE FOR ENGRAVING SOUNDINGS FOR HYDROGRAPHIC CHARTS; HYDROGRAPHIC OFFICE, JAPANESE NAVY.

what is sufficient for given similar hydrographical basins. The author intimates very properly, however, that it is applicable only to conditions similar to those behind the standard dam and spillway.

To illustrate this very forcibly, let us take the Rio Grande at El Paso, whose basin in the arid region is radically different from those in New England. At El Paso, the drainage area of the Rio Grande is about 50,000 square miles, running through the whole of New Mexico into Colorado. For length l_1 of spillway, we would, according to the formula, have

$$l_1 = 1.017 \sqrt{\frac{50,000}{8,000}} = 2.542.5$$

As a matter of fact, the river at El Paso flows over a masonry dam about 400 ft. long with a maximum depth not exceeding 7 ft. The formula, therefore, gives a length 6.35 too great.

Again, taking the actual length of spillway of 400 ft. and solving for depth h_1 of water, we have

$$h_1^{\frac{2}{3}} = \frac{1.017}{400} \sqrt{\frac{50,000}{8,000}} \times (12)^{\frac{2}{3}} = 264.17$$

$$\therefore h_1 = 4'.15$$

This gives a calculated depth 5.88 times the actual. On the contrary, many of the small tributaries of the Rio Grande coming in laterally from the sharp rocky slopes of the adjacent mountains of New Mexico have abnormally high and rapid rates of maximum discharge due to local but heavily concentrated water falls in the rainy season of July and August. Such maximum discharges last but an hour or two, but, in such cases the above formula would, evidently, give spillways too small.

In the above calculations, the data relative to the Holyoke dam given by Mr. Frizell are taken for insertion in the formula. The results are not quite exact in the decimal places.

In the arid West, where the great dams and reservoirs of the future are going to be created for irrigation, there are, unfortunately, no well established standards for the extremes of hydrographical conditions found there. This, however, is no argument against the value of the formula in its legitimate sphere of application.

Yours truly, J. L. Campbell.

Koeltztown, Mo., Aug. 12, 1901.

Sir: I am sure Mr. Frizell needs no apology for favoring us, in advance of future publication, with the interesting communication on "Length of Wasteways," which appears in your Aug. 8 issue. Indeed, we may cap his classical precept with this other one: "Bis dat qui cito dat."

The first problem which Mr. Frizell proposes to solve in the above communication, as I understand it, is this: An existing dam controlling a given drainage area, with an overflow or spillway of given length, has a maximum depth of water, h_1 passing over the lip of the spillway. It is desired to determine the proper length of another spillway controlling a different drainage area of the same meteorological character, under the condition that the depth of water above the lip of the spillway shall be the same in both cases.

Mr. Frizell solves the problem by making the two lengths of spillway homologous sides of roughly approximate similar figures, and deduces:

$$l_1 = l \sqrt{\frac{A_1}{A}},$$

in which l and l_1 are the respective lengths of the two, and A and A_1 their corresponding drainage areas.

Now, although the square root of drainage area is a factor in determining the proper length of a spillway, I think that in the above special case, the true relation is:

$$l_1 = \frac{l\ A_1}{A}.$$

The character of the two areas being the same, the run-off in cubic feet per square mile per second of each is directly and simply as the number of square miles they contain. On the other hand the discharging capacity of the two spillways per running foot is identical, since the depth of water over them is the same. It is difficult to see therefore why the length of spillway in this special instance, should not vary simply as the areas which they control. If we conceive the drainage area to be divided longitudinally into two equal parts by an imaginary line cutting the spillway in half, each half of the latter provides for the flow of half the area, and varies from total length as 1 to 2, the same as the area, and not as 1 to $\sqrt{2}$. The same reasoning would apply in the case of two separate watersheds, one twice the area of the other, with the same depth of water going over their spillways.

In the first example given, the basis of comparison is the Holyoke dam, length of spillway in round numbers 1,000 ft., controlling the prodigious drainage area of 8,000 square miles, with a maximum depth, over the spillway, of 12 ft. Here it is evident that each running foot of overflow takes care of 8 square miles of drainage area. The proper length of another spillway controlling a drainage area of 2,173 square miles, with the same depth of water passing over it, is then found by the method proposed to be 530 ft. That is to say, in this case, each running foot only takes care of about 4 square miles of similar area. It is difficult to see why, with the same depth of water, the second spillway should not be 272 ft., each foot taking care of 8 square miles, as in the first case.

Mr. Frizell also gives a formula for the case when not only the drainage areas vary, but also the depth of water over the spillway. I am unable to check the results obtained because the depth h_1 appears to be taken as that directly over the lip of the overflow and not the depth below the level of still water in the reservoir. It is impossible to calculate the discharge without knowing what this latter value is, for there is no fixed relation between the two.

It appears to me that the only safe, and at the same time the simplest course to pursue in designing a spillway, is to ascertain what maximum freshet flow in (say) cubic feet per square mile per second it will probably be necessary to provide for and give the spillway such length and depth as will discharge the same. The tentative formula for length which I always use in preliminary calculations is:

$$L = 20 \sqrt{A}, \qquad (1)$$

in which L = length in feet, and A = drainage area in square miles. For the proper depth corresponding to the length so obtained, I use:

$$D = \frac{\sqrt[3]{Q^2 A}}{16} \qquad (2)$$

in which D = depth in feet from lip of spillway to level of smooth water in reservoir, and Q = cubic feet of run-off per square mile of area, per second. A is the same as before. A value of Q which is not infrequently sufficient is 64. In this case the formula reduces to:

$$D = \sqrt[3]{A} \qquad (3)$$

Applying (1) and (3) to the Holyoke dam we would have, L = 1,800 ft. and D = 20 ft. I think the small depth of 12 ft. observed at Holyoke indicates that there was a very large consumption of water going on simultaneously with the flow over the dam. But after all, such enormous watersheds cannot be subjected as a whole to the same rules which may govern each of their parts, for the same meteorological conditions cannot prevail over their entire area at once. They are laws unto themselves, and must be studied on their individual merits. In designing spillways for water supply reservoirs, it is proper to assume the most unfavorable case of no draft on the reservoir at the time of occurrence of the maximum freshet flow. I may here remark upon the great practical utility of always providing a capacious "blow-off" situated well down towards the bottom of the reservoir, which can be opened in case the water continues to rise dangerously fast.

I would like to take this occasion to present for discussion a formula for the requisite amount of storage to assure a certain daily supply from a given watershed, or drainage area. It is evident that the governing factors in the problem are the daily demand and the minimum yearly yield of the watershed. The greater the latter in relation to the former, the less storage will be required, and vice versa. It has occurred to me therefore that the correct ratio would be obtained by making the yearly consumption (365 times the daily) a mean proportional between the desired storage and the minimum yearly yield. Expressed in a formula this gives:

$$S = \frac{C^2}{Y}, \qquad (4)$$

in which S = necessary, or at least desirable, storage; C = yearly consumption, and Y = yearly minimum yield; all in the same unit, cubic feet or gallons.

I believe the above formula will give, perhaps in all cases, the maximum storage required. And I should be greatly gratified, and I believe it would be of general interest, if hydraulic engineers would compare these formulas, (1) to (4), with observed facts in their own practice, and let the results be known in your columns.

E. Sherman Gould.

Yonkers, N.Y., Aug. 10, 1901.

P. S.—If h indicates height of smooth water above crest, and not merely depth on crest, the relation which Mr. Frizell establishes between h and h_1 is correct. The general formula should then read:

$$l_1 = l \frac{A_1}{A} \left(\frac{h}{h_1}\right)^{\frac{3}{2}}$$

Which, moreover, can be proved by the standard formula for discharge over weirs. E. S. G.

(Proofs of the above letters were submitted to Mr. Frizell, and we append his reply.—Ed.)

Sir: The note on wasteways, published in your issue of Aug. 8, was presented for the criticism of the engineering profession and I am gratified to find it receiving such attention.

I will first devote a few words to Mr. Gillette's five reasons against my proposition. In respect to the first, I would observe that the maximum flow of a stream seems to stand upon a different footing from the aggregate or average flow. In ordinary floods, one part of the drainage area may contribute in much greater measure than another; but in the great floods which occur but once in a generation or more, all tributaries concur in making their greatest contribution and local peculiarities disappear. Two streams of equal drainage ground and different climatic conditions will differ much less in their maximum flow than in their aggregate flow. In great streams floods are of longer duration and less relative magnitude than in small ones.

Mr. Gillette's second reason shows that the water moves faster in the upper part of the basin by reason of the greater slope; his fourth, that it moves slower in the upper part of the basin by reason of the small cross section of the stream. These statements are both true and largely neutralize each other. The force of the third reason is not clearly perceived. If the flow of the stream is increased by the entrance of a tributary, the drainage area is also increased in corresponding proportion. Regarding Mr. Gillette's fifth reason, pondage appertinent to ordinary water-power dams cuts but a slight figure in a flood. As to storage reservoirs, the accumulation of water during the progress of a flood is liable greatly to modify my proposition, as I have intimated in reference to the Wachusett reservoir, and as I have pointed out in "Water Power," p. 200, et seq.

Next, as to the difficulties perceived by Mr. Gould. He has doubts as to the meaning of my symbols h h_1. They mean, in each case, the height in feet of pond level above crest of wasteway. He thinks the formula $l_1 = l \frac{A_1}{A}$ would be preferable when applied to different areas in the same river basin. It strikes me that if he would apply such a formula to the Connecticut River basin and Holyoke dam with a low value of A_1, say $A_1 = 8$, he would perceive some incongruity in the idea of a wasteway 1 ft. long to discharge the flood waters of 8 square miles.

Of course, if A_1 is half of A, the aggregate annual flow over l_1 will be half that over l. A wasteway, however, is not proportioned with reference to the aggregate or average flow of its drainage area, but with reference to the maximum quantity of water that claims right of way over it at the same time, and a little reflection will show that this cannot be directly proportional to the extent of drainage area commanded by it.

Mr. J. D. Campbell's remarks hardly call for any comment, he apparently realizing perfectly well that to make the formula applicable to the arid region, the standard dam must be located in the arid region. I do not know whether the dam at El Paso has stood long enough to show the maximum flow, or whether it is the wasteway of a reservoir large enough to greatly modify the application of the formula. I will venture this remark, however: Judging from the behavior of the Colorado of Texas, which heads in the arid region, the Llano Estacado, it appears to me that a wasteway of 400 ft. to discharge the flood waters of 50,000 sq. miles is destined to lead to unpleasant surprises.

Mere pro and con arguments, however, count for little in scientific questions. The proposition

$$l_1 = l \sqrt{\frac{A_1}{A}} \text{ or } l_1 = l \sqrt{\frac{A_1}{A}} \frac{n}{h_1} \sqrt{\frac{h}{h_1}}$$

must rest upon its agreement with observed facts. It cannot be directly compared with the facts of nature because nature does not furnish wasteways, and existing wasteways are not constructed on infallible principles. Nevertheless it can be put in a shape to admit of such comparison.

Let q be the maximum flow per second per square mile going over l and q_1 that for l_1. We have

$$A\ q : A_1\ q_1 = l : l_1 = \sqrt{A} : \sqrt{A_1}.$$

Whence

$$q \sqrt{A} = q_1 \sqrt{A_1}, \text{ and } q_1 = q \sqrt{\frac{A}{A_1}}; \text{ also } q : q_1 = \sqrt{A_1} : \sqrt{A}.$$

That is to say: The flow per square mile to be provided for is inversely as the square root of the drainage area. This proposition admits of comparison with known facts.

Mr. Emil Kuichling, in his report on water supply for the proposed enlargement of the New York state canals, has given a table of the maximum flow of streams. By maximum flow he understands the highest observed flow per square mile. We, however, must understand by maximum flow from a given area, the highest flow that has ever been observed from such an area. Taking the Holyoke dam and its appertinent drainage area as the standard, we will compare his and other results with results of our formula. In computing the flow over the Holyoke dam, I use formula (25) of "Water Power," which being free from empirical coefficients, may be expected to give as correct results for great values of h as it is found to give for small values. I must remark that I have, on more careful examination of records, found the maximum depth on the dam to be 12.5 ft. instead of 12 ft., as formerly stated, viz., in April, 1862.

AREA OF ABOUT 1 SQUARE MILE.—Mr. Kuichling gave for the Witgendorfbach in Saxony, a flow of 1,116 cu. ft. per second per square mile on an area of 1.3 square miles. Our formula gives

$$\frac{3.09 \times 12 \times \sqrt{12.5} \times 1,017}{8,006} \sqrt{\frac{8,006}{1.3}} = 17.35 \sqrt{\frac{8,006}{1.3}} = 1,362.$$

AREA OF ABOUT 4 SQUARE MILES.—Mr. Kuichling

the roulette is drawn under weight across the surface of the land areas. A lever operated by the hand raises and lowers the roulette for the purpose of skipping those parts of the chart which represent water.

The subdividing machine consists of a long base, mounted on which is a drum, on the surface of which is engraved a series of radial lines radiated from the smallest size of subdivisions to be used to the largest size. On the front of the base there is a sliding carriage carrying a spring point designed to fall in the engraved radial lines on the drum, also a point used for engraving the subdivision lines on the plate. The machine being set parallel to the border of the chart, the engraving point is brought to the center of the line between two divisions. The drum is then moved laterally until the central radial line is in coincidence with the spring point on the carriage. The carriage is then moved to the right or left of the next division line of the border. The drum is then revolved until the last radial line is in coincidence with the spring point of the carriage. The drum is then fastened and this first line is engraved on the border scale, the carriage is then moved to the second radial line and the corresponding line engraved, and so on until the last line of the drum is reached. Then the drum is loosened and shifted forward until the first line is once more in coincidence with the spring point on the carriage, which is again moved to each line in succession until the end is reached, and so on until the entire border is subdivided.

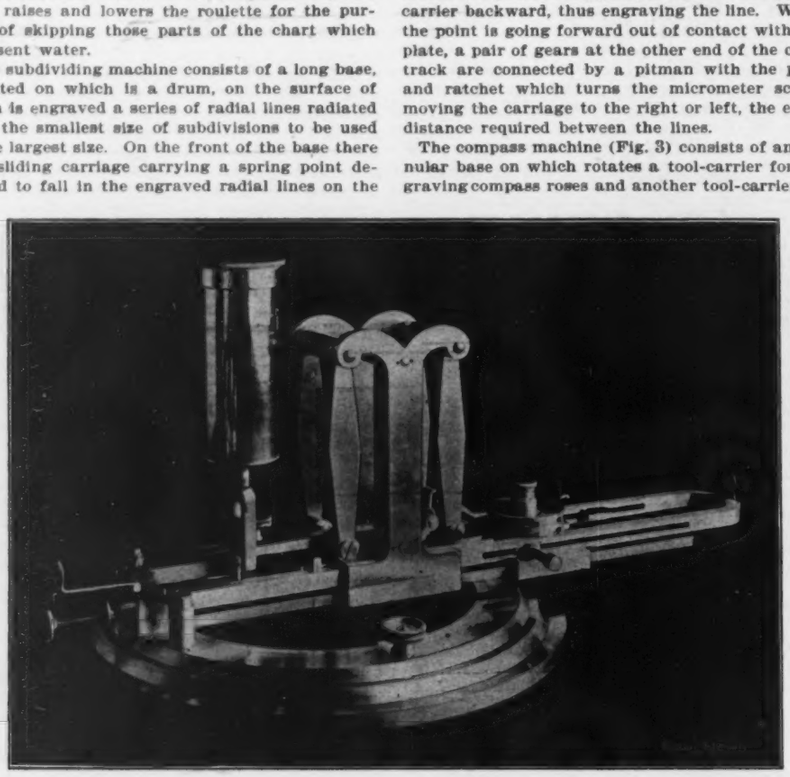


FIG. 2. MACHINE FOR ENGRAVING BORDERS FOR HYDROGRAPHIC CHARTS; HYDROGRAPHIC OFFICE, JAPANESE NAVY.

The border shading machine consists of a base on which slides a cross track operated by twin screws, which are controlled by worm and wormwheel. On the cross track is a carriage operated by a micrometer screw controlled by a pawl and ratchet. On the carriage is mounted an engraving point, which moves backward and forward for engraving straight lines, which lines can be at any angle to the border scale lines. As stated before, it is designed to engrave the U. S. Hydrographic Office symbol of mud bottom, which consists of a series of hachure lines engraved about 1-50-in. apart and about 3-32-in. in length. After the first range is engraved the machine is moved forward the exact amount of the length of lines, the engraving point is shifted one-half of the distance between the lines, and the second range is then engraved. This operation is then repeated until the desired amount of symbol is engraved.

For shading the borders the distance between the lines is about 1-133-in., and the handle at the extreme end of the cross track is turned, which in its turn operates a bevel-gear, which meshes with a smaller gear on the sliding carriage. This, by its rotary movement, operates a pitman conected with with a lever which first raises the point from the plate and moves the point-carrier forward, then lowers the point to the plate and moves the point-carrier backward, thus engraving the line. While the point is going forward out of contact with the plate, a pair of gears at the other end of the cross track are connected by a pitman with the pawl and ratchet which turns the micrometer screw, moving the carriage to the right or left, the exact distance required between the lines.

The compass machine (Fig. 3) consists of an annular base on which rotates a tool-carrier for engraving compass roses and another tool-carrier for lettering these devices. The base is oriented on the plate in proper position, and a true north compass consisting of a circle of 360 degree lines, and inside of that circle a circle of 128 lines representing the mariner's points. After this is engraved the compass is set to the desired magnetic variation when another degree circle and mariner's point circle, both at the magnetic variation, are engraved inside of the true compass. The compass engraving mechanism is then moved from the base and the lettering mechanism substituted. This mechanism operates in exactly the same manner as the sounding machine, except that it engraves in circles, instead of in straight lines.

The multi-point divider consists of a cylinder through which are cut two series of radial lines, one opposite the other. Mounted on a shaft running through the center of this cylinder are as many points as there are radial slots. The points pass through the slots, one end being flushed with the surface of cylinder, the other end extending about ¾-in. When the shaft is rotated the points are pressed into the wider or narrower part of the group of slots and thus made to recede from or to approach each other, maintaining a uniform distance between themselves. When the two outside points are brought to the limits of the space desired to be subdivided, the intermediate points will indicate the positions of the subdivisions.

For the particulars from which this description has been prepared we are indebted to Queen & Co., who, it may be stated in passing, have been commissioned to supply a set of these machines to the German Government.

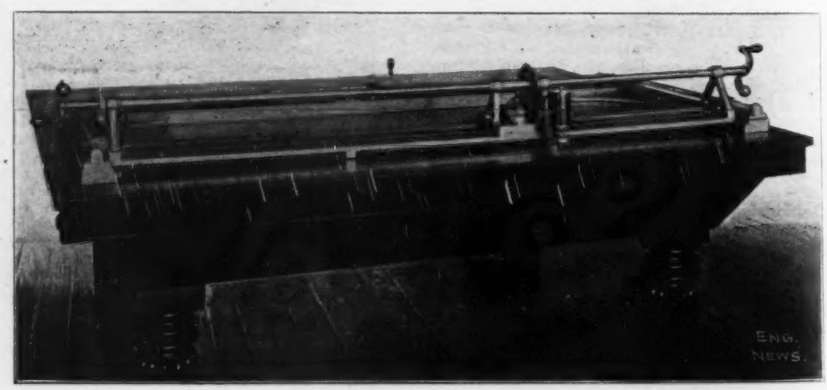


FIG. 3. MACHINE FOR ENGRAVING COMPASS ROSETTES FOR HYDROGRAPHIC CHARTS; HYDROGRAPHIC OFFICE, JAPANESE NAVY.

A CENTRAL COMPRESSED AIR POWER PLANT FOR QUARRY WORK NEAR LAKESIDE, O.

We illustrate in the accompanying cut a combination air compressor and steam power plant recently installed to operate extensive quarries located near Lakeside, Ohio. This power plant was installed by the Ingersoll-Sergeant Drill Co., of New York city, and the following description of it has been furnished to us by Mr. J. J. Swann, of that company.

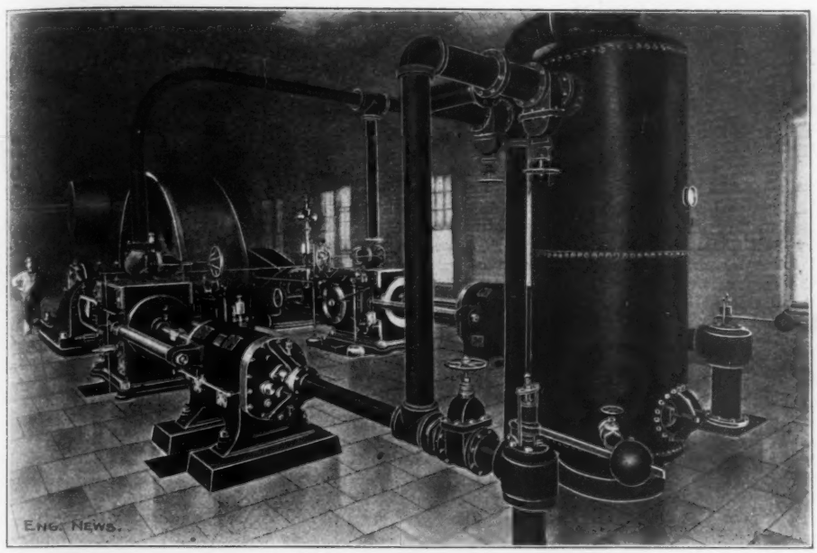
This engine embodies a number of novel features and is, we are inclined to believe, the forerunner of a type of air compressors likely to find a very large field of usefulness in the future. The equipment consists of two 500-HP. Corliss engines of the latest improved Tangye design and embodying all of the latest features in this class of engine which have demonstrated their permanent value. Each of these engines is connected to a crank disk which is mounted on the end of a single shaft, and between them is an 18-ft. fly-wheel, with a 52-in. face, from which a 50-in. belt runs to a heavy countershaft. This in turn belts off to one No. 8, one No. 7½, one No. 6 and one No. 4 Gate's crushers, and also furnishes power for two No. 3 pulverizers and three buhr mills and the necessary elevators, screens and auxiliary apparatus. It will be noticed that this is quite a departure from the ordinary form of compressor, in which the fly-wheel performs no other function than to equalize the motion and maintenance of the steady running of the compressor.

The air cylinders, which constitute the compressor portion, are coupled tandem to the steam piston tail rods, as is customary in the Corliss air compressors manufactured by the Ingersoll-Sergeant Drill Co. Rigid distance rods are used to hold the cylinders at an exact distance from the steam cylinders, so that no strain is thrown on the foundation. At the same time this arrangement permits the clearance in the air cylinder to be reduced to a minimum, which in turn increases the volumetric efficiency of the air compressor.

In the illustration the air cylinders appear to be very small in comparison to the size of the steam cylinders; and this is really the case, as the steam cylinders perform a double duty. They drive the belt wheel as well as the air compressor cylinders. For operating the machine equipment of the plant about 600 HP. is required, while the air cylinders, when compressing to 110 lbs., call for about 350 HP. The engine operates at a constant speed, as it is necessary that the belt drive be perfectly steady, irrespective of the load on the air compressor cylinders, which, of course, varies from minute to minute, according to the air consumption.

The engine is provided with a standard Corliss governor, which has demonstrated its ability to handle a varying load and is regarded as the standard form of regulator for large engines, and, in addition, the air cylinders, which are of the well known piston inlet type, are provided with a special form of inlet regulation, which operates entirely independently of the engine governor and is controlled by any variation in the pressure of the air in the receiver. In principle it is a form of "balanced cylinder valve," which opens or closes the

inlet for supplying air to the cylinder. Thus, when but little air is being used from the receiver, the inlet governor automatically shuts the inlet passage until it is nearly closed, so that very little air can be drawn into the cylinder. As the demand for air increases there is a tendency for the pressure to drop, which influences the regulator, causing it to open to a degree which is exactly dependent upon the variation in receiver or pipe line pressure. The result is that more and more air is taken into the cylinder as the demand for air increases until the full limit of the cylinder is reached. It will be seen that this device also controls the power that is consumed in the compression of the air and nicely adjusts matters so that as the need for air decreases the amount compressed, and consequently the power consumed, is decreased in an exact ratio.



A COMBINATION AIR COMPRESSOR AND STEAM POWER PLANT FOR QUARRY WORK.
Ingersoll-Sergeant Drill Co., New York, N. Y., Builders.

The compressed air obtained is fed into a large receiver, from which it is drawn through the main pipe line to supply the various requirements of the scattered quarries. The principle use of the air is for operating Ingersoll-Sergeant rock drills in and about the five different quarries. Several of the quarries are within a few thousand feet; one is fully a mile away from the compressor, and another is 1¼ miles distant in a different direction. In addition, air is used to drive a special pump operating a water supply system which takes its water from a lake; also for an air-lift pump in a well some distance from the power station. It is used for hoists; to drive several pumps for the drainage of the quarries; for blacksmith forges; in the repair shops of the Lake Side & Marblehead Ry., and for a variety of other uses.

The object of the proprietors of these quarries was to concentrate the generation of power at one point so that the expenses for fuel and general operation and the cost for engineering force would be reduced to a minimum. With a central power equipment, the coal and supplies are landed where it is convenient and where they are cheaply handled. This arrangement also permits of the most efficient boilers and of an engine of the highest economy, and reduces the wastes of all sorts incident to a considerable number of portable boilers and engines scattered over a wide area, the best of which, when operated by men whose minds are largely taken up with other work, are uneconomical, unsatisfactory and to some extent unsafe. The engineering force is in this way also reduced to a minimum, and the depreciation of the machinery from all causes is greatly decreased.

The purpose of having two independent engines coupled to the same shaft is to admit of the greatest possible flexibility of the equipment and to insure continuous operation in case of accident. During a certain period of the year when the demand for air is slight, owing to the partial closing down of work, this arrangement permits of either side being disconnected in a very few minutes, leaving the load to be taken care of by one engine and one compressor cylinder. This at once reduces fuel consumption to about one-half. By the use of a steam compressor, air is produced at a much lower cost than would be possible if a belted compressor were used, because the double transmission of power is avoided and a more certain operation is insured due to the avoidance of belts. The direct connection of the air piston to the piston rod has been demonstrated to be the ideal arrangement for an air compressor, as it reduces the friction and decreases the wear and other losses. In the future, should the demand for power increase beyond the 600 HP. allowed for the belt drive, the air cylinders may be removed and connected to a smaller independent pair of Corliss engines, which can be installed at any time, thus allowing the large engine to be used for power purposes alone, in which case it would deliver its full capacity of 1,000 HP.

In connection with the out-door portion of the equipment, the fact may be mentioned that several miles of uncovered air mains are in use. These lead to the different quarries and are provided with taps and valves so that the flexible hose or temporary pipes can be quickly connected and power obtained literally "at a moment's notice." To avoid "freezing of the air," so called, which is experienced at certain times of the year, a special separator has been installed, which removes after compression practically all of the moisture contained in the air, so that the air arrives at the apparatus to be operated in a dry condition and exhausts after performing its useful work without the moisture which might otherwise freeze.

THE DESIGN OF ECONOMIC STREETS AND PAVEMENTS.

By Halbert Powers Gillette.*

There seems to be a well-settled conviction among engineers that by survival of the fittest a certain few classes of pavements have become standard, and that little remains for the engineer to do but to select the particular standard design best fitting the traffic and the purse of the taxpayer. In other words, the design of a pavement no longer seems to require inventive ability on the part of the engineer. I am, however, convinced that there is a great deal yet to require inventive genius in the truly economic design of so apparently simple a structure as a street or road.

To begin with, the functions of a pavement are in no text-book clearly enumerated and defined. Following the precedent established by Macadam, we find Byrne and other modern writers stating that the real function of a pavement is to keep the subsoil dry, for they say any earth will support the heaviest of wagon loads if only kept well drained. Macadam even went so far as to assert that as the subsoil does ultimately carry the wheel load, no pavement at all would be needed were it not necessary to shed the rain and to provide a smooth surface. It is hard to understand how a philosophic man could fall into so grievous an error as Macadam did in this instance, except upon the hypothesis that being a man of one idea, he held to the one fact that his mind had grasped to the exclusion of all others. Drainage was Macadam's hobby. Now, as a matter of fact, the shedding of water is distinctly a secondary function of a pavement, the primary function being to distribute the concentrated wheel load over a sufficiently large area of subsoil. If the pavement be thick enough, the subsoil may be saturated with water, yet it will not yield under a load; on the contrary, a macadam pavement much thinner than 4 ins. will not uphold a heavy wheel load on a sand subsoil no matter how dry it may be. In the face of such facts how absurd, then, is Macadam's widely-copied generalization that the primary object in pavement building is to provide a roof for shedding water.

The three functions of a pavement in the order of their importance are: (1) To distribute the concentrated wheel load over a sufficient area of subsoil; (2) to act as a roof, keeping subsoil dry; (3) to furnish a smooth surface, reducing rolling friction.

Wet clayey soil has a much less supporting power per square inch than dry, which makes the second function above given of great importance. Of wet sand the same cannot be said, for were it possible to keep a sandy subsoil merely damp it would support a greater load and therefore be preferable to dry. In fact, a slightly porous pavement on a sand subsoil would be desirable were it not for sanitary considerations.

Whether the soil be clay or sand, however, it is absolutely necessary to provide a pavement of thickness sufficient to reduce the concentrated wheel load to such a pressure per square inch that the soil will sustain it without appreciable settlement. The necessary thickness obviously varies with the character of the soil and its degree of moisture. On a certain sandy soil containing considerable loam there is a road that has stood up well with only 4 ins. of macadam, except in a low and poorly-drained section where at times not only the subsoil, but the lower course of the macadam is saturated with water; there 12 ins. of macadam has been found necessary. I have made a large number of experiments upon the supporting power of soils, but they are of little value to any one who has not seen the soil itself, so will not give them at this time.

Where a mass of loose fragments such as broken stone is spread upon a soil it is evident theoretically that the smaller the fragments the greater will be the area of subsoil over which a concentrated wheel load will be distributed. Experiment confirms this conclusion. Therefore, where a macadam road is being built over sand, the smaller the stone in the lower course of macadam the better, for less stone will be forced down into subgrade by the steam roller. After the stone has been rolled and bound, and has become a monolith, the size of the fragments is a matter of less importance; it is during construction that much may be saved by bearing the above-stated fact in mind.

If, as we have seen, the prime function of a pavement is to distribute pressure, the question very naturally arises whether it may not be well to use as cheap a foundation material as possible to accomplish this purpose, and reserve the more expensive material to form a thin wearing coat that will also serve to shed water. This is in fact now done, but not to the extent that it should be; for we find many cities invariably using 6 to 8 ins. of concrete for foundations where a layer of broken stone, slag, cinders or gravel would form a much cheaper and better foundation. If found desirable, such a foundation might be covered with 2 to 4 ins. of concrete. If broken stone or slag is used, the interstices should be filled with sand or the like, which may be done either by spreading the sand over the layer of stone and washing it into the voids with water, or by mixing sand and stone with shovels and depositing it like concrete.

On a certain street, when the inspector was away for a time, the contractor entirely omitted putting any cement in the concrete foundation, simply mixing stone and sand, wetting thoroughly and ramming to place. A little cement was sprinkled over the top so that the fraud would not be discovered. I have watched the section of pavement where this was done, and after several years of use it stands up as well as the portion where cement was used in the concrete. From which it is evident that many pavements are made needlessly expensive by the use of cement, especially where the subsoil is not argillaceous, and cement may to advantage be omitted from the con-

*791 Powers Block, Rochester, N. Y.

of one's conscience being a sufficient incentive, it will remain noticeable that nothing so stirs most men into action as the sight of a dollar that may be secured by exercise of a little ingenuity.

If it were to become the American practice to require the builder to submit his own designs for street and road work, guaranteeing maintenance for a period long enough to insure durability, who can doubt that one would witness a revolution in the art and science of road and street construction? Incidentally, the engineering profession would have opened up to it another field where brains would receive substantial recognition such as can be secured in no way other than one where competition is free and open, the prizes going to the best men.

50-TON WRECKING CRANE; SOUTHERN RY.

The Southern Ry. has recently added to its equipment a 50-ton steam wrecking crane, which is shown in the accompanying cut. The car upon which the crane is mounted is of steel construction throughout, with 24-in. I-beams for the sills and plate brackets carrying rollers upon which rest the outrigger beams used for extending the base of the machine when making heavy lifts with a long reach. There are three outriggers, each composed of a pair of I-beams. When in place for transportation the outriggers are secured by pins through the hangers and beams, as shown. The car is 24 ft. 3 ins. long over all and 9 ft. 6 ins. wide. It is mounted on a pair of extra-heavy diamond frame trucks, the axles having bearings 6 × 10 ins. The machine is fitted with M. C. B. couplers and air brakes. The wheel base is 17 ft. 6 ins., and the weight of the entire machine, in running order, is 166,000 lbs.

The engine has two horizontal cylinders 9 × 12 ins., which, with the gearing, are mounted in heavy frames on a turntable with circular rack. The engine supplies all power for hoisting, slewing and raising or lowering the boom. The vertical boiler and the water tank serve as counterbalances. The boom consists of a pair of I-beams, connected by ties, diagonals and batten plates and reinforced at the outer end by plates riveted to the top and bottom flanges of the beams. Eyebars attached to the head of the boom carry grooved sheaves, while similar pulleys are carried by other eyebars attached to the anchor rods. A wire cable connects the two sets of sheaves, and is hauled in or paid out, as required, to vary the reach of the boom. The maximum height of the crane is 15 ft. The hoisting capacity of the machine, with outriggers extended, is 50 tons at a reach or radius of 16 to 20 ft., or 40 tons at the maximum radius of 25 ft. Without the outriggers, the capacity is 15 tons at 16 ft. radius, 10 tons at 20 ft., or 8 tons at 25 ft.

The wrecking equipment on this road is under the direction of the Motive Power Department, and wrecking cranes are located centrally, with a working radius of about 100 miles. After each trip the machines are thoroughly inspected, repaired, if necessary, and kept ready for service at short notice. Each crane is in charge of a regular man, preferably an engineman who has had experience in the shops and running engines. When not engaged on the crane in making repairs or at wrecks he is employed in the shops at such work as may be assigned to him. When wanted at night he is called by the man whose duty it is to call enginemen and firemen for their trains. The address of each man connected with the wrecking outfit is on file in the office of the master mechanic. There is at present only one of the 50-ton cranes above described, but it has already been employed in lifting heavy engines and cars, and has rendered very effective service. For information as to the crane and the wrecking system we are indebted to Mr. W. H. Thomas, Superintendent of Motive Power of the Southern Ry., and to the builders of the machine, the Bucyrus Co., of South Milwaukee, Wis.

50-TON WRECKING CRANE; SOUTHERN RY. Bucyrus Co., South Milwaukee, Wis., Builders.

THE OCCURRENCE AND TREATMENT OF CAISSON DISEASE IN ENGINEERING WORKS.

A paper describing the rebuilding of the Glasgow Bridge (a masonry arch structure constructed by Telford in 1833), was recently read before the Institution of Civil Engineers. In this paper, its author, Mr. Benjamin Hall Blyth, referred briefly to the founding of the river piers at depths of from 84 ft. to 98½ ft. below water level by pneumantic cylinders, and describes the experiences of the workmen in the compressed air as follows:

In sinking the cylinders, it was found that up to a pressure of about 30 lbs. per sq. in. the men were able to work continuously; that is, 8-hour shifts in 24 hours. Above that depth discomfort increased very rapidly and at the extreme pressure of about 43 lbs. or 44 lbs. per sq. in., it was almost impossible for men to work at all.

During the discussion which followed the paper the remarks which we have quoted came in for considerable attention, and much of the information brought out is of such general interest that we print the discussion nearly in full below:

Sir Alexander Binnie observed that there was one small detail with regard to the Glasgow Bridge to which he wished to draw attention, namely, the clear indication given by Mr. Blyth of the limit within which work under compressed air could be carried out. In the years 1880 and 1891, in conjunction with Sir Benjamin Baker, he had been considering the feasibility of carrying the Blackwall Tunnel under the Thames. They had had to rely much more on theory than on practice, and ultimately the conclusion had been arrived at that 35 lbs. per sq. in. would be probably the limit of pressure which could be endured by human beings working under compressed air. He was glad to see that the result at Glasgow had fairly well proved that to be the case—it being stated that when a pressure of 40 lbs. per sq. in. had been reached it had been almost impossible to get men to work economically. No doubt naval men could relate wonderful instances of men working at very great depths below water, involving higher pressures; but the men in such cases really worked for a comparatively short time and for some special object. In engineering work, however, which had to be carried out day by day, probably for months, and it might be even for two or three years, it became a very important matter to decide what was the limit of pressure under which men could be worked economically—and by economically he meant having regard to something more than pounds, shillings and pence, because it was not economical to use up human energy in a manner detrimental to health. Mr. Blyth's paper afforded a very useful indication of a limit beyond which it was not possible to go. A valuable contribution to the subject had recently appeared in the medical press from the pen of Dr. Wainwright, who had been medical adviser in the construction of the Waterloo & City Railway under the Thames. The conclusions at which Dr. Wainwright had arrived were very similar to those come to by Dr. Snell, the medical officer who for three years had observed the working of the men under compressed air at the Blackwall Tunnel. Many theories had been advanced as to how the compressed air really acted on the human system. It had been suggested that it acted on the nervous system. Any ill that human flesh was heir to might be said to be a derangement of the nervous system, but the two medical men he had mentioned began with the proposition that the illness was due to two things: (1) increase of pressure directly; and (2) increase of the duration of exposure to pressure. Of course, the changes could be rung on increased pressure and increased time in an infinite variety of ways. A great many theories had been started as to the evils of locking out with great rapidity, which had been said to be the cause of the illness. Indirectly it might be so, but it was not the real cause. Both Dr. Wainwright and Dr. Snell had proved very conclusively that the evils which arose from working in compressed air were due to absorption of the air through the surface of the skin, the mucous membrane, and the lungs; and they had shown clearly, from the experiments of Dalton, that the blood would absorb oxygen, nitrogen, and carbonic acid in certain definite proportions. Unfortunately carbonic acid was absorbed by the blood much more rapidly than either oxygen or nitrogen. It was well known that when men worked in tunnels or underground works, the air became more or less vitiated, whether electric light was used or not. Many of the processes carried on, as well as the breathing of the workmen, tended to produce carbonic acid, and that carbonic acid was absorbed in a larger proportion than were the ordinary constituents of the atmosphere. Apparently what happened was that when the system having been charged with the gases through the blood, was suddenly relieved on coming out, the gases, acting probably through the capillary vessels, endeavored to discharge themselves through the surface of the skin, causing excruciating pains in the joints and sometimes in the muscles, and leading in bad cases to paralysis and even death. The way in which those gentlemen had proved that to be the case was very simple, and their procedure was one with which all who had had to do with compressed air were familiar. When a man was afflicted in that manner, the way to cure him was to replace him at once in compressed air at a pressure equal to, or perhaps a little higher, than that under which he had been working previously, and then to reduce the pressure of the air by gradual leakage. If a man was working at a pressure 30 lbs. per sq. in. above that due to the atmosphere, that pressure should be reduced gradually in, say, 45 mins., an hour, or two hours. That plan has been found generally to be almost a perfect cure. As soon as a man suffered from the violent pains—and they were so excruciating as to cause an ordinary able-bodied navy to howl in a frightful manner—he should be placed again in the compressed air, when the pain would cease at once. It was almost surprising to see within how few minutes after running up the pressure the pain ceased. As the pressure fell by slow degrees, pain was not felt, because through the lungs, and the surface of the skin, and in other ways, the man was gradually getting rid of the gases which had been forced into his system. He believed that that theory was rapidly passing into well-established practice.

Mr. A. H. Haigh observed that it was certainly to be regretted the author of the paper on the Glasgow Bridge had not gone into full details with regard to the cylinders, which apparently were the chief feature of the work. It would have been very interesting to hear more about them, especially at the present time, when the use of

crete—but the omission should also occur in the specifications and not as in the case just cited.

Broken stone and sand will ordinarily form a cheaper foundation than macadam made of broken stone bound with screenings; for it requires about 1⅔ cu. yds. of stone and screenings to make 1 cu. yd. of rolled macadam, whereas with unscreened stone, which is about ⅓ voids, and sand enough to fill the voids, the cost per cu. yd. of foundation is about as follows:

1 cu. yd. loose unscreened stone at $1	$1.00
⅓ cu. yd. sand at 60 cts.	.20
Mixing and placing with labor at 15 cts. hr.	.30
Total cost cu. yd. foundation	$1.50
Add for superintendence and profit	.25
Price per cu. yd.	$1.75

Whereas, if natural cement be added to form concrete, about one barrel will be required at 75 cts., and about 25 cts. more labor per cu. yd. will be required to secure proper mixing of the cement. Macadam will cost almost as much as natural cement concrete, due to the greater quantity of stone.*

Wherever a granular mass is used for the foundation of a pavement it is desirable to have all the voids filled in order to entirely prevent movement of the fragments under the jarring of passing loads.

If the fragments are angular and well compacted, there is less need of filling the voids, but if the fragments are round it is imperative.

Sand alone has often been used as a foundation for brick and other pavements, but frequently with very unsatisfactory results on account of uneven settlement. Sand can, however, be made quite as unyielding as gravel simply by filling the voids with fine dust. For this purpose it would be well if cities, especially those in the middle west, would secure pulverizing mills and grind about one-third of the sand used to powder, then mix with the coarser sand and puddle well in forming a foundation. No rolling is necessary. Water, if supplied in abundance, will puddle sand that contains sufficient fine dust until it is almost as hard and unyielding as concrete. Engineers who have seen the adamantine consistency of quicksand after it has dried out will bear witness to the statement just made. It is evident that on a sand subsoil if fine dust be spread and washed in, the supporting power of the soil will be so greatly improved that a very thin foundation will suffice. In this connection it may be well to outline a method for improving the bearing power of argillaceous soils. After the soil has been soaked artificially, or preferably by rain, and then partially dried off, roll it with a steam roller using the picks in the rear wheels. The picks will punch and leave innumerable little well-like holes about 4 ins. deep in the soil, and in so doing will compress the soil laterally. If these holes be filled with sand, cinders or the like, the supporting power of the soil will be wonderfully improved at slight expense.

The filling of the holes is most cheaply done by dumping the loads of sand at intervals, spreading it into the holes with a Shuart grader. The sand in the holes acts like so many small piles, supporting the foundation by carrying the load down and thus spreading a concentrated load over a greater area of subsoil.

In discussing economic pavement design, we have thus far dwelt upon the foundation and subsoil; we may now consider briefly the wearing coat. Wood and stone block pavements are gradually but surely falling behind in the race for supremacy; wood because it is in the long run not so cheap as brick; stone because it is more expensive than asphalt, and scarcely more durable where the traffic is great. The noise caused by a stone block pavement is alone a good enough reason for its rejection, even where the cost of maintenance is less than asphalt.

Vitrified brick, if laid flatwise, is almost as cheap in first cost as cedar block, and when this is realized I look to see such cities as Detroit entirely discontinue the building of wooden pavements. Brick are as yet always laid edgewise in street paving, thus giving a wearing coat 4 ins. thick. Since it is the function of the foundation to distribute the load, a thickness of 4 ins. in the wearing coat is not required unless for some other reason. When a brick pavement has worn down about ¾-in. on an average, there are so many spots where the wear has been three times greater, that an entire renewal becomes necessary; for this reason 3 ins. seems to be the maximum thickness necessary in brick pavements, while if the traffic is so light that wear is inappreciable, as upon most residential streets, 2¼ ins. is an ample thickness, and this may be secured by laying the ordinary "pavers" flatwise. It may be argued that when so laid the brick will crack or tilt up under a heavy load. That they neither crack nor tilt is proven by an examination of brick sidewalks across which heavy loads have passed over flat bricks; and it may also be observed that in spots where brick has been worn until only 1½ ins. thick, the brick remain uncracked.

In many small cities where pavements of brick on edge (4 ins.) are to be seen, the wear is infinitesimal. It requires slight knowledge of mathematics to ascertain that were the money saved by building a thinner (2¼-in.) wearing coat of brick compounded at ordinary rates of interest the amount would be sufficient to entirely renew the pavement every 15 to 20 years, if it required renewal, which in most cases it would not.

There are at present just four kinds of surface coats for pavement purposes that are both economic and desirable for other reasons, namely, (1) asphalt, (2) brick, (3) macadam, (4) tar macadam or asphalt concrete. Which shall be chosen depends upon local conditions, the fancy and pocketbook of the taxpayer. Many tables have been published giving, upon a scale of 100, the relative weight to be allowed for first cost, maintenance, smoothness, cleanliness, noisiness, etc. The pavement showing the highest percentage is to be selected. As well prepare tables for the selection of a suit of clothes. Given the money available, and knowing the fancy of those who furnish it, the engineer will require no table to guide him in the selection of a suitable wearing coat.

The term wearing coat has led some engineers to reason that the surface that wears most slowly is the most economic, which is far from being so. Granite is extremely hard, and is so far superior to brick or asphalt block that were the rate of attrition the sole criterion of durability, it would never pay to use anything but granite where it is available. Granite and other stones wear round by the chipping off of corners, and in comparatively few years a stone pavement becomes so rough and slippery that it must be renewed. Brick wears far more slowly than macadam, but when worn only a fraction of its thickness, the entire surface coat has to be renewed on account of its very uneven wear. Macadam, on the contrary, needs only to be picked up and rerolled to put it in as good condition as new, except, of course, for the material lost by wear. Asphalt wears more slowly than brick, but it rots out in 15 to 20 years, so that where the wear of traffic is slight, brick should always be selected if economy alone governs. Tar macadam will be found subject to the same deterioration by rotting as asphalt. I would therefore suggest that where such pavements are built the whole thickness should not be bound with tar or asphalt, but only the top 2 ins. —a thickness that will wear out before it rots out.

While upon the subject of durability, a few words as to the maintenance of macadam may not be out of place, for cost of maintenance is the ground upon which it is frequently rejected. Macadam "ravels" in dry weather, but it is a mistake to suppose that, therefore, it requires constant sprinkling. Over some of the recently-built New York State roads a sprinkler passes several times daily, doing little good at great expense. What a macadam road does require is an occasional drenching when and where it begins to show signs of raveling, which is accomplished by going over a short section time and again with the sprinkler during the night; for if the sun is up the water has not time to soak in before it is evaporated. Done as suggested, the cost of maintenance is greatly reduced. A thin coat of sand over the surface will further reduce the rapidity of evaporation.

We have considered briefly the quality and thickness of foundation and wearing coat of an economic pavement; we next pass to a consideration of the width and transverse profile. While the width of a street between fence lines is ordinarily 4 to 6 rods, the paved roadway should be as narrow as will permit traffic to be maintained without congestion. Street cars should never be placed in the center of a residence street, for the tracks cut up the street, forming two narrow roadways, one on each side, thus crowding traffic into narrow channels and quickly wearing the surface coat into ruts.

Car tracks should be located, as shown in the illustration, at the side of the street, leaving a clear roadway of moderate width. Certain residents will object to this location on the ground of danger to carriages passing over the car tracks at entrances to private grounds; but experience has proven this danger to be more imaginary than real, for accidents are no more frequent in the one case than in the other. The danger of alighting from one car and being struck by another coming from the opposite direction is moreover entirely avoided by the arrangement shown.

For illustration, a four-rod street has been selected. Starting from the fence line the first 4 ft. is occupied by a cement walk, then comes a space of 1 ft., then a 6-ft. bicycle cinder path, followed by a 4-ft. space occupied by trees, then a 5-ft. car track, a 3-ft. space to the curb, and a 20-ft. paved roadway.

The bicycle traffic has become very great within recent years, a large portion of almost every roadway being occupied by "wheels." This is not as it should be, for while a thick pavement is needed to properly distribute a concentrated wagon wheel load of 2,000 lbs. or more, it is a useless extravagance to provide the same class of pavement for a bicycle wheel load of 100 lbs. A thin and very inexpensive pavement of cinders, as shown, better accommodates wheelmen and at far less cost. Furthermore, a cinder path is never muddy after rains or from excessive sprinkling, as roadways usually are, but is always pleasant to ride over. A point that will cause criticism at first is the narrowness of the paved roadway, which is in fact the best feature of the design, for the great saving in first cost, in maintenance and in sprinkling will enable a city to improve two miles at the same price it ordinarily costs for one mile, while every class of traffic will be amply provided for. Were similar designs ordinarily adopted we would not see cities like Salt Lake City, with its enormously wide residence streets, unpaved because of prohibitive cost.

I desire in closing to call attention to the reason for the absence of true economy in existing designs of roads and streets, and the lack of any great progress in this branch of engineering. In bridge building American engineers lead the world. Why? Solely because of our American method of calling for bids upon a bridge of given span to carry a given load, leaving to the bridge contractor the submission of the design he intends using. Each bridge builder must consequently employ a skilled engineer, and the keen competition that exists under such conditions quickly brings to the front the truly skillful designer, and sharpens his wits, with the result that old "standard" designs are cast aside and far better ones produced. Abroad it is customary for the engineer employed by the corporation, civil or politic, to draw the design upon which builders submit tenders.

Small wonder that when they come to compete with our American designers they are beaten "hands down;" for we take advantage of a law of human nature that they do not, namely that "no man will incur a risk without prospect of an adequate reward." To execute an entirely new design always involves the element of risk, and as under existing conditions the foreign engineer sees no adequate reward in making risky changes in design, he very wisely sticks to the old and tried standards. A builder, under a competitive system, on the contrary, has every incentive to employ an engineer who posseses inventive genius. His financial success depends upon the economic merit of the structure he builds; and although "theorists" may talk till doomsday about the rewards

*For detailed cost of macadam, see "Economics of Road Construction."

compressed air for tunnelling was extending. The subject of compressed air was dismissed in the paper in a couple of sentences; but he thought the matter unquestionably came within the province of the engineer, and so was a subject for discussion. Putting together the statements in those two sentences, he would surmise that, after trying to work with a pressure of 44 lbs. per sq. in., the results in the matter of compressed-air sickness had been such that they had warned off other men whom it had been desired to take on for the work. He would like to know whether the sickness to which the men had been subject had occurred while working in the compressed air, or after coming out of it; and he hoped some fuller details might be given by the author. Although compressed air had been used in foundation work for something like 70 years, and probably for 30 years in tunnelling, information on this matter was still scanty; but uniformly it had been found that when a pressure of 45 lbs. per sq. in. was reached there resulted an inordinate amount of sickness and a heavy death rate. Observation tended to show, however, that the cause was not the actual pressure to which the human frame was subjected, and that the effects known as the "bends" were due to a secondary cause. As Sir Alexander Binnie had mentioned, it appeared that the immediate cause of illness was an abnormal percentage of carbonic acid. In the matter of cylinder work it was rather difficult to contrive that the fresh air pumped into the cylinder should reach the workers or become thoroughly mixed with the vitiated air before it was ejected. The case, of course, was different in a tunnel where there was an open face of ballast, and the air was admitted at the lock and escaped through the face. The latter case was the least trying to miners and laborers. But when tunnels entered such clay as was met with in the London basin, or some equally impervious material, the same difficulty occurred in getting to the workers the fresh air pumped into the tunnel. The tunnel under the Thames at Charing Cross which had recently been completed for the Baker St. & Waterloo Ry. had been driven through open ballast, and a good many observations had been made which had led to conclusions which it might be useful to bring before the Institution. It had been found that when 130,000 cu. ft. of air per hour were being driven through, which provided more than 8,000 cu. ft. man per hour, the sickness had been very slight, scarcely any cases for medical treatment having occurred; but when only 1,300 cu. ft. to 2,000 cu. ft. per man per hour were being driven, with a clay face, the majority of the cases had occurred. Dr. Wainwright, the medical officer appointed by the contractors to attend at the works, had found during his observations of the percentage of carbonic acid in the atmosphere that when driving the larger quantity of compressed air through the tunnel the percentage of carbonic acid present had been between 0.06 and 0.07%. When driving only between 1,300 cu. ft. and 2,000 cu. ft. of air per man per hour the percentage of carbonic acid had been between 0.08 and 0.1%. The difference between the two had been due to the difference in the nature of the tunnel face. The material in the ballast had been so open that when a small area had been exposed for setting back the timbers the air had escaped so freely that it had been impossible to keep the pressure up without driving through that large quantity of air; whereas in clay as much air could not be driven through the tunnel as had been desired, because it had been difficult to get the men to keep open the blow-pipe provided for that purpose. Dr. Wainwright's remedies or palliatives were slow diminuation of the pressure and the administration of ergot, with the occasional application of liniments and hypodermic injection of morphia. It had been found that in most cases slow diminution of pressure was the most effective, but in one case it had been shown to be utterly useless. The patient in that case had been a man who had previously suffered from the bends, and had worked in and suffered from the pressure at the Blackwall Tunnel. The mechanical effects on the body occurred during the locking into and out of the compressed air, but those were minor and infrequent if proper care was taken. The genuine "bends" occurred some time after egress, and the number of cases seemed to increase very rapidly with the proportion of carbonic acid in the atmosphere. In the case of an excess of carbonic acid under ordinary atmospheric conditions, the result to the organism was that a condition of asphyxia, or something approaching it, was set up; not from the poisonous nature of carbonic acid, but merely from the want of the oxygen which it displaced. In compressed air there was still a sufficiency of oxygen; but as liquids absorbed a large amount of carbonic acid, in some cases as much as their own volume, it appeared that three or four hours under the pressure was required before the men suffered from its effects. It seemed that an inordinate amount of the gas was absorbed, probably by the blood, or not given off in the ordinary way in the lungs. The inconvenience which resulted after the removal of the pressure might be due to the expanding gas not having escaped from the blood, and being discharged into the joints and tissues of the body; or possibly to mechanical obstruction in the vessels through which circulation took place. If not, then the cause had yet to be determined. Out of about 120 miners and laborers who had been employed in the compressed air on the tunnel previously mentioned, 88 men had formerly worked in compressed air, and 47 cases of bends among 40 men had been treated by the medical officer. Thirty-four cases had been spread over more than four months, and in 25 of these the men had previously worked in compressed air. When work had been going on in the clay face the medical officer had treated 13 cases in 12 days. The general conclusion seemed to be that compressed-air sickness was a function of the pressure, of the quantity of carbonic acid present, and of the time during which absorption had been taking place. Hence, higher pressures might be used by employing shorter shifts, purity being uniform. The relations between the several factors remained to be more exactly determined. In the case of the tunnel he had referred to, every provision for the proper regulation of workers, the protection of their health and the alleviation of suffering, had been provided by the contractors, Messrs. Perry & Co. The serious results had been very few, and no deaths had occurred.

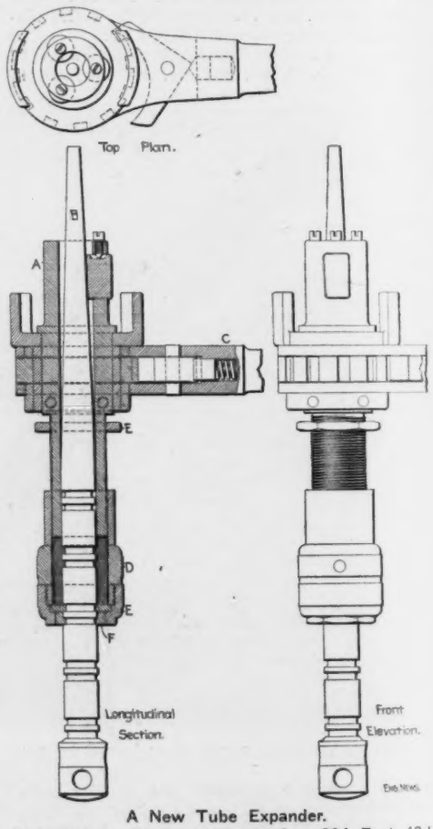
Dr. Kennedy asked under what pressure the work in the Baker St. and Waterloo Railway tunnel had been carried out.

Mr. Haigh replied that almost from the time when the soffit of the tunnel had reached the open ballast to the end of the work, the pressure had been equal to the full hydraulic head of the water, varying with the tide between 24 lbs. and 32 lbs. per sq. in.

Mr. J. M. Moncrieff remarked that the chief interest in the description of this bridge was in the cylinder sinking which involved such high air pressures. It was of importance to know whether any means of constant leakage had been provided, for the purpose of ventilation of the working chamber, other than that afforded by the escape of air below the cutting edge, presuming that the material through which the cylinders passed was of such a nature as to allow air to escape in this manner, and that the pressure was always sufficient to prevent the sealing of the bottom of the working chamber by water, which particulars were not, however, given in the paper. He believed it to be of the greatest importance that such means of constant leakage were provided when working under high pressures. No information was given as to whether the men employed were subjected to actual suffering, as distinguished from discomfort, from the effects of the high pressures in the first four cylinders. If so, he would like to know whether the men so affected had been thoroughly healthy and abstemious, and had been examined by a medical man with a knowledge of such work. He had recently had experience at New Redheugh Bridge in the sinking of 12 cylinders to depths ranging from 65 ft. to 79 ft. below high-water level, with pressures up to 34 lbs. per sq. in., and the following particulars might be of interest. The number of men employed in regular work in the working chamber in sinking these cylinders had been about nine, and of these all except one had been more or less affected with "bends" and vomiting. Three cases of severe temporary paralysis had occurred, but of these one man had been physically unfit, and had been only once under pressure, and that for a short time. He had not been examined by a medical man before entering the cylinder. Two of the men still suffered slightly from bends. Only one case of illness had occurred with pressures under 20 lbs. per sq. in.; but when the pressure had risen to between 30 lbs. and 34 lbs., three cases (two of them severe) had occurred in three days after, after which the men had not worked when the pressure was above 30 lbs., which had been possible by ceasing work while the tide was high. The quantity of air supplied per man had also been largely increased, with good results, but he could not give any precise figures as to this. Under the lower pressures, the gangs had worked in shifts of 9 hours, divided into three sections of 2 hours' work in the cylinder and 1 hour of rest. With pressures between 26 lbs. and 30 lbs. the men had worked in shifts of 7 hours, divided into two sections of 3 hours in the cylinder and 1 hour's rest between. As a rule the men had been under medical examination before working under heavy pressure. A means of constant leakage from the roof of the working chamber had been provided in the shape of a cock on the bottom end of a ¾-in. pipe carried up from the roof to above water level. The men, however, had not liked the hissing noise in the chamber, and therefore had frequently kept the cock shut and defeated its object. He had had no hesitation in entering the cylinders when at their finished depths, with correspondingly high pressures, to finally examine the foundation before sanctioning the concreting up of working chamber and access tubes, and on only two occasions had he suffered any inconvenience whatever. One of these had occurred when a slight cold had caused difficulty in blowing out the drum of one ear as the pressure rose in the lock, and the other when examining the foundation level of a finished cylinder, on which occasion, after being down between 20 minutes and 30 minutes, he had begun to experience a feeling of pressure in the head. He had at once asked the men whether the leakage cock was open, and had been surprised to find that it was not. A few minutes after having the cock opened, the discomfort had ceased. When this had occurred, the cutting edge had been bedded on hard shale, and very little air could escape below it. He had rarely visited the cylinders at any other time than when at finished depths. The resident engineer, Mr. George Huntley, representing his firm on the work during the 21 months occupied in the sinking of the 12 cylinders, had been in the habit of paying frequent visits to the working chambers, and on only one occasion had he suffered the slightest inconvenience, and then only as a result of going under a pressure of 32 lbs. early in the morning, before having breakfasted. During the sinking of the cylinders two rather alarming accidents had occurred, but happily without serious results. In the first case, when the cylinder had been sunk to about 28 ft. below low-water level, and the pressure had been about 15 lbs. per sq. in., by some means the inner door of the material lock had been forced open at the same time that the outer door was open. As a result the compressed air had been immediately released and the cylinder had dropped 4 ft. The men working in the chamber had hastily come out, much alarmed but otherwise uninjured by the experience of having the pressure instantly lowered from 15 lbs. above the atmospheric pressure to its normal value.

A NEW TUBE EXPANDER.

The tube expander shown in the accompanying illustration possesses a number of features of interest and novelty. Three rollers are held loosely by set screws in the casing (A). Instead of revolving the taper pin (B) and feeding it by continued hammering upon the head, the entire roller case is revolved by means of the ratchet lever (C). Applying the power to the case instead of to the pin is said to increase the speed of the work, and also to facilitate rolling imperfect interior tube surfaces, such as lumpy welds, etc. The taper pin is fed by means of the screw feed nut (D), thus avoiding all hammering upon the pin. At the bottom of the feed nut, a thin hexagon nut (E) is



A New Tube Expander.
Made by the Watson-Stillman Co., 204 East 43d St., New York City.

shown which acts as a depth gage. By removing the upper cap (E) of the feed nut the split interlocking ring (F) may be shifted from one double slot to another upon the taper pin, thus making it possible to roll tubes varying in diameter from 2¾ to 3¼ ins. The rollers are made with the proper taper to bring their surfaces parallel with the interior surface of the tube. This tube expander is manufactured by the Watson-Stillman Co., of 204-210 East 43d St., New York city, to whose courtesy we are indebted for the drawing accompanying this article.